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ENVIRONMENTAL EFFECTS OF MERCURY DISCHARGES FROM A CHLOR-ALKALI/PULP MILL COMPLEX AT MARATHON, ONTARIO

DECEMBER, 1978

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1978

Ontario

Ministry
of the
Environment

ENVIRONMENTAL EFFECTS OF MERCURY DISCHARGES FROM A CHLOR-ALKALI/PULP MILL COMPLEX AT MARATHON, ONTARIO

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INTRODUCTION

In May, 1976, an intensive survey was conducted to determine levels of mercury discharged by a chlor-alkali plant/pulp mill complex operated by American Can of Canada Limited at Marathon, Ontario.

Concurrent investigations were carried out to evaluate the amount of mercury being discharged in the liquid effluent and to assess the impact of the mercury emissions on the atmosphere, soils, water, lake bottom sediments and fish in the surrounding area.

The work has been compiled by the Industrial Abatement Section, Thunder Bay District, Air Quality Assessment, Northwestern Region and Water Resources Assessment, Northwestern Region.

SUMMARY

Mercury discharged in the liquid effluent from the chlor-alkali plant was within Federal regulations under normal operating conditions. During abnormal wastewater batch discharges, however, permitted mercury levels were exceeded. Further, the amount of mercury discharged in the combined liquid effluent from the chlor-alkali plant and pulp mill was about an order of magnitude higher than from the chlor-alkali plant alone.

Because of the total amount of mercury being discharged from the complex to Lake Superior, the Ministry of the Environment served a Control Order on American Can of Canada Limited which in effect gave the Company the option of completely closing down the mercury cell chlor-alkali operation or converting the operation to a process which did not use mercury. The Company chose to completely close down the mercury cell operation. The plant ceased operating on August 31, 1977. As a result of this decision, the amount of mercury being discharged from the complex will be substantially reduced.

This survey confirmed the need to eliminate all sources of mercury in the chlor-alkali plant and in all storage tanks or in other facilities in the plant or pulp mill where mercury sludges or contaminants may have collected. The Company has been required to eliminate these sources in conjunction with the elimination of the mercury cell process.

Very high mercury concentrations were found in depths of up to 15 cm (6 inches) in soil near American Can's chlor-alkali plant and pulp mill in Marathon. All evidence indicated that airborne emissions from the chlor-alkali plant were the source of local soil contamination. The quantity of mercury in these soils was conservatively estimated at 281 to 482 kg (618 to 950 lb.). Coal-burning operations at the mill were judged to contribute little to mercury contamination of the surrounding area. The ultimate fate of mercury in contaminated soil was not established, but limited sampling indicated that insignificant amounts were lost to surface run-off water.

A localized area of soil with less severe mercury contamination was found near the Company's warehouse. Spillage from stored mercury-laden waste was implicated as the cause.

Air monitoring near the chlor-alkali plant revealed that atmospheric mercury levels were significantly elevated, but below the Ontario standard. Concentrations decreased with increasing distance from the source. Slightly elevated levels were recorded near ground level at the warehouse site, but readings were virtually zero in air at the clarifier sludge disposal area and at the mercury waste burial site.

As previously reported in 1972, and further substantiated by this report, mercury concentrations in fish continue to be above the acceptable level of 0.5 micrograms per gram (μg/g) as set out by the Food and Drug Directorate of the Department of National

Health and Welfare in 1971. All lake trout captured in Peninsula Harbour during 1975 and 1976 contained levels in excess of 0.5 µg/g. Thirty-eight percent of these fish were above 1.0 µg/g.

Mercury levels in sediment in the immediate vicinity of the outfall and Jellicoe Cove reached levels as high as 112 µg/g and diminished as distance from the discharge increased. However, at distances in excess of 500 metres, concentrations still exceeded background levels of Lake Superior.

Preliminary analysis of water in Jellicoe Cove suggests a similar pattern of mercury contamination decreasing with increasing distance from the mill outfall; apparently associated with the methylation of mercury in the sediments.

Biological evaluations of the sediments in the adjacent waters suggest severe pollution of the sediment concomitant with the wastes discharged from the mill and chemical plant.

The work conducted in 1976 supports earlier work done by this Ministry in defining elevated levels of mercury in fish and sediment, and disruption of bottom fauna communities. Little or no improvement in the quality of the aquatic environment of Peninsula Harbour has occurred since the earlier study in 1969.

BACKGROUND INFORMATION

As a result of an excessive number of days during which Federal regulations on mercury discharges in chlor-alkali plant effluents were broken, the Ministry of the Environment decided to do an in-depth study of the Marathon plant effluent to endeavor to determine the cause.

A vegetation and soil assessment survey in August, 1975, indicated the presence of mercury contamination in the vicinity of American Can's chlor-alkali plant in Marathon. Intensive soil sampling in November of the same year established more precisely the levels and extent of contamination. Snow sampling in the same area during the past two winters also revealed elevated mercury concentrations and showed that mercury distribution patterns in snow and soil were about the same. Mercury levels in both substrates decreased with increasing distance from the chlor-alkali plant. All evidence clearly indicated that airborne emissions from the chlor-alkali plant were responsible for the presence of high mercury values in the nearby terrestrial environment.

During 1975 and 1976, surveys were undertaken to evaluate the effects of industrial wastes from Amercian Can of Canada Limited at Marathon on the aquatic biota, sediments and water of Peninsula Harbour, and adjacent Lake Superior. This report presents the findings of fish flesh analysis for mercury, benthic fauna community distribution related to communities previously documented in 1969, and chemical analysis of water and sediments. Mercury concentrations are compared with values documented for sediment samples collected in 1971, (1).

Appendix D is an edited version of an earlier report by B. P. Neary, Inorganic Trace Contaminants Section, Laboratory Services Branch, describing the method of analysis for mercury and a comparison of the analyses which were performed at three separate laboratories.

DESCRIPTION OF STUDY AREA

Peninsula Harbour is located approximately 290 road kilometres east of Thunder Bay on the north shore of Lake Superior. The study area consists of essentially two regions, Peninsula Harbour and a portion of Lake Superior immediately adjacent to the south side of The Peninsula.

Peninsula Harbour contains numerous small bays and is separated and sheltered from the open waters of Lake Superior by Hawkins Island on the west side and peninsulas on the north and south sides. The southern peninsula (named, The Peninsula), extends approximately 1.25 kilometres in a westerly direction toward the open water of Lake Superior. The northern peninsula which is unnamed, reaches out in a southwesterly direction.

The main population centre in the area is the Township of Marathon (population 2,220) (2) which is located at the base of The Peninsula. The townsite of Marathon extends from the south shore of Jellicoe Cove, the southern-most bay in the harbour, across the neck of The Peninsula to the shore of Lake Superior. The main industry in the town is the bleached kraft pulp mill owned and operated by the American Can of Canada Limited. In conjunction with the pulp mill, this Company also operated a chlor-alkali plant. The location of Peninsula Harbour, the industrial complex and the Township of Marathon are shown in Figure 1.

The waters of Peninsula Harbour are used mainly for supply of process water and disposal of mill wastes by the American Can of Canada Limited operation. This industry withdraws approximately one hundred and thirteen million litres per day (25 MIGPD) of water from the Jellicoe Cove area for the production of about 453 metric tons (500 tons) per day of bleached kraft pulp and for use in the chlor-alkali plant. The chlor-alkali plant produced chlorine, caustic soda, sodium hypochlorite, sodium chlorate and hydrochloric acid. The wastewater discharges from the mill complex amount to approximately the same volume as the withdrawal. Sections of the Harbour (Jellicoe and Beatty Coves) are also used by the industry for the storage of logs.

The Township of Marathon discharges approximately 1.36 million litres per day (.30 MIGPD) of effluent from its primary sewage treatment plant to Lake Superior on the south side of The Peninsula. Water supply for the Township is obtained from three wells.

There is presently no commercial fishing in Peninsula Harbour.

MERCURY IN THE LIQUID EFFLUENT

CHLOR-ALKALI PROCESS DESCRIPTION

The chlor-alkali plant of American Can of Canada Limited manufactured chlorine, caustic soda, sodium hypochlorite, hydrochloric acid, sodium chlorate and sulphur liquor for use in the Company's 500 ton-per-day kraft mill located at the same site. The prime products, chlorine and caustic soda, were produced by the electrolysis of brine in electrolytic cells featuring graphite anodes and mobile mercury cathodes.

Brine was continuously fed to the cell where it was partly decomposed in one compartment (called the electrolyzer) between a graphite anode and a mobile mercury cathode, forming chlorine gas at the anode and sodium mercury amalgam ($Na(Hg)$) at the cathode. The amalgam flowed continuously to a second compartment (called the denuder) where it became the anode to a short circuited graphite cathode in an electrolyte of sodium hydroxide solution. The amalgam was decomposed into sodium hydroxide, mercury and hydrogen gas. The mercury was washed and returned to the cell to be re-used as a mobile cathode, the caustic soda was diluted to 50% and sent to storage. Before the stored caustic soda was fed to the pulp mill, it was filtered to remove impurities including mercury.

The hydrogen gas from the denuder was water cooled in a direct contact tower designed to condense mercury vapour. Condensed mercury was collected in a rough trap located at the bottom of the tower and returned to the cells. The cooled gas was either vented to the atmosphere or retained for hydrochloric acid production. The amount of mercury emitted was related to the temperature of the hydrogen gas, increasing with increases in the temperature of the hydrogen gas. The hydrogen vent was one of the two prime sources of mercury emitted to the atmosphere, the other being the ventilation fans through which cell room air was exhausted.

Hydrochloric acid was manufactured periodically by feeding hydrogen and chlorine gases to a hydrochloric acid burner. The acid was formed as a gas and then dissolved in water to form liquid hydrochloric acid which was sent to storage.

Sodium hypochlorite was produced by the chlorination of crude caustic soda. The chlorination was carried out in two ways. The first method involved passing chlorine gas directly into a hypochlorite reactor containing crude caustic soda. In the second method, chlorine gas and crude caustic soda was passed countercurrently through a packed caustic scrubber tower. The chlorine gas exit stream from the packed tower was vented to the atmosphere. This second method permitted the disposal of chlorine gas from various parts of the chemical plant, such as the depleted brine stripping tower gas cooler, gas from the sulphuric acid pump tank and weak cell gas.

Sodium chlorate was and still is produced by electrolyzing a slightly acidic solution of brine. This produces a hypochlorate solution containing a little free hypochlorous acid. By adding hydrochloric acid to this solution, the hypochlorous acid is oxidized by the chlorine ions to produce chlorate, chlorine and hydrogen.

Sulphur liquor is produced by dissolving solid sulphur in white cooking liquor from the pulp mill. When the required sulphur stength is reached, the sulphur liquor is stored for use in the pulp mill.

SOURCES OF MERCURY EMISSIONS IN THE CHLOR-ALKALI PLANT

Wastewaters which had been in direct contact with mercury were collected in a trench inside the chemical plant and were treated before discharge to Lake Superior.

Mercury came in direct contact with water in the following places: amalgam return lines washwater, cell inlet boxes washwater, cell outlet boxes washwater, hydrogen cooling tower washwater, and mercury pump tank washwater. These sources of contaminated wastewater were collected and returned to the caustic feedwater tank. The cellroom floor washings, cellroom sink drain, and safety shower water were collected and returned to the salt chest. The testing bench sink drains, drinking fountain, safety shower, hydrochloric acid burner trough drain, floor spray at base of sulphuric acid pumps, chlorine cooling tower cooling water, pump glands and seals, drain from the chlorine filter dump tank heaters, condensate from the space heater, process room floor washings, hydrochloric acid absorber cooling water, and brine filter backwash were collected in a trench inside the chemical plant and were treated to remove mercury.

The treatment of wastewaters to remove mercury consisted of the addition of:

(1) hydrochloric acid or sodium hydroxide for pH control;

(2) sodium sulphite to oxidize any hypochlorite in the wastewater;

(3) sodium sulphide to react with mercury and form a mercury sulphide precipitate; and

(4) ferric chloride as a flocculating agent to aid in the settling of the precipitate.

After the precipitate from the chemically treated wastewaters had settled out, the clarified liquid was decanted and discharged directly to Peninsula Harbour in Lake Superior.

Wastewaters which did not come in direct contact with mercury were collected in a ditch outside the plant and also discharged to Peninsula Harbour. These sources were: heating and ventilating discharge water from the plant entrance area and office area, chlorate cell cooling water, rectifier cooling water, air compressor cooling water, refrigeration cooling water, compressed chlorine coolers, hydrochloric acid burner cooling water, chlorine compressor cooling water, air dryer cooling water, and cooling water from the raw brine coolers, the hypochlorite coolers, and the sulphuric acid coolers.

EFFLUENT SAMPLING PROGRAM AND RESULTS

Twelve sampling stations were established in the chlor-alkali plant and the pulp mill (see Figure 2). Names of the stations were as follows:

Station 0	Treated Effluent Batch Discharge
Station 1	Chlor-Alkali Plant Sump to Treatment Tanks
Station 2	Inside Sewer - Process Room
Station 3	Caustic Soda (Final Product)
Station 4	Inside Sewer - Exit Cell Room
Station 5	Chlor-Alkali Plant Discharge to Lake
Station 6	Storm Drainage and Seepage
Station 7	Cooling Water Ditch
Station 8	Cooling Water and Pulp Mill Sump Overflow to Lake
Station 9	Alkaline Bleachery
Station 10	Acid Bleachery
Station 11	Main Mill Effluent

Stations 1, 2, and 4 comprised mercury contaminated wastewaters before treatment. Stations 5, 8, 9, 10, and 11 represented points of direct discharge to Lake Superior.

Each station with the exception of Station 0, treated effluent batch discharge, was sampled hourly from noon May 17th, 1976 until 1800 hours May 18th and again from 0800 hours May 19th until 2330 hours May 19th. Each sample was analysed for mercury.

Station 0, treated effluent batch discharge, was sampled at 5-minute intervals whenever a batch was being discharged. This occurred on May 17th, May 20th, and May 21st, 1976.

Other sources sampled less frequently were service water at mill intake, sodium hypochlorite, hydrochloric acid, sodium chlorate, unfiltered brine and filtered brine, and the four main sources to the cooling water ditch. These four sources were chlorine compressor cooling water, hydrogen vent precooler water, brine heat exchanger water, and the combined brine heat exchanger water and sodium hypochlorite cooling water.

All samples taken were analyzed in the Ministry's Thunder Bay Laboratory. Portions of these samples were submitted for mercury analysis in the Ministry's Toronto Laboratory. A percentage of each portion was also analyzed for mercury in a temporary laboratory in the Marathon High School. Comparison of results from the three laboratories and the method of analysis are discussed in Appendix D.

The following averaged results were obtained from each station.

Station Number	Location	Hg Concentration - ppb Average	High	Low
0	Treated Effluent Batch Discharge May 17th	4,284	80,500	35
	May 20th	290	6,580	88
	May 21st	93	2,390	14.2
1	Chlor-Alkali Plant Sump to Treatment Tanks	3,083	7,300	560
2	Inside Sewer-Process Room	300	44,800	4,500
3	Caustic Soda (Final Product)	139	224	36
4	Inside Sewer-Exit Cell Room	19,201	30,000	3,730
5	Chlor-Alkali Plant Discharge to Lake	49	146	3.9
6	Storm Drainage and Seepage	43	168	15
7	Cooling Water Ditch	2.6	5.6	1.1
8	Cooling Water & Pulp Mill Sump Overflow to Lake	3.9	15.0	1.3
9	Alkaline Bleachery	12.4	19.0	5.3
10	Acid Bleachery	4.7	10.3	1.7
11	Main Mill Effluent	4.5	8.8	2.0
	Service Water at Mill Intake	0.13	0.24	0.07
	Sodium Hypochlorite	2,960	3,790	1,650
	Sodium Chlorate	11,400	16,200	8,500

The analysis for all samples taken are recorded in Appendix C.

The following averaged flow rates were obtained during the survey:

	USGPM*
Mill water intake	17,500
Main Mill effluent	7,000
Alkaline Bleachery	4,000
Acid Bleachery	5,700
Cooling Water Ditch	800
Storm Drainage or Seepage	15

*United States Gallons Per Minute

An assumption made for calculation purposes was that the flow associated with the Main Mill effluent was discharged at all times at Station 11. In reality, this effluent occasionally overflows at the pulp mill sump and is therefore partially discharged at Station 8.

The amount of wastewater discharged per treated batch averaged 42,000 US gallons. This data was provided by the Company and confirmed by observation.

The following average daily production rates were obtained from the Company during the survey:

	TPD*	lbs/day
Chlorine	31.0	62,000
50% Caustic Soda	70.0	140,000
Sodium Hypochlorite	120.0	240,000
Sodium Chlorate Solution	10.5	21,000

*Short Tons (2,000 lbs.) Per Day

MERCURY LOADING IN THE CHLOR-ALKALI PLANT EFFLUENT

The major sources of mercury loading in the chlor-alkali plant effluent were the treated mercury wastewater, cooling water, and seepage from the brine chests. The mercury wastewaters were collected and treated as a batch when the wastewaters in the treatment tank reached a certain level. This level was normally reached about every two days. As a consequence, the amount of mercury in the chlor-alkali plant effluent varied markedly from day to day.

During the survey, from May 17th to 21st, three treated batches were discharged.

In this report, the following situations were considered:

1. Mercury loading for a day with no treated batch discharge.
2. Mercury loading for a day with a normal treated batch discharge.
3. Mercury loading for a day with an abnormal treated batch discharge.

Situation 1 - Mercury loading for a day with no treated batch discharge of treated wastewater

In situation 1, only Stations 5, chlor-alkali plant discharge to the lake, and 7, cooling water ditch, were involved.

At Station 5, where the discharge consisted mainly of storm drainage and seepage from the brine chests, flow averaged 15 USGPM. Therefore, the amount of mercury discharged was calculated to be:

$$= (15 \times 24 \times 60)\ \frac{\text{USG}}{\text{day}} \times 8.34\ \frac{\text{lbs}}{\text{USG}} \times 49\ \text{ppb} = 0.009\ \text{lbs Hg/day}$$

At Station 7, the cooling water from the chlor-alkali plant averaged 800 USGPM. The amount of mercury discharged was calculated to be:

$$= (800 \times 24 \times 60)\ \frac{\text{USG}}{\text{day}} \times 8.34\ \frac{\text{lbs}}{\text{USG}} \times 2.6\ \text{ppb} = 0.025\ \text{lbs Hg/day}$$

Therefore, the total amount of mercury discharged directly to the lake for the average day with no discharge of treated wastewater was 0.034 lbs.

Federal regulations state that mercury in liquid effluent discharged from a plant (defined as a plant designed or operated for the production of chlorine and sodium hydroxide by means of any industrial process involving the electrolysis of sodium chloride) may be deposited in waters frequented by fish if the quantity deposited by the plant in any day does not exceed .005 lbs per ton of chlorine produced by the plant in that day.

The plant produced an average of 31 tons of chlorine daily during the survey. Thus, the allowable amount of mercury which could be discharged was .005 x 31 = 0.155 lbs. Therefore, for a day in which no treated wastewater was discharged, the plant was within the prescribed regulation.

Situation 2 - Mercury loading for a day with a normal treated effluent batch discharge

In situation 2, Stations 5, chlor-alkali plant discharge to the lake, and 7, cooling water ditch, were included with Station 0, the May 20th treated batch discharge. The May 20th discharge was designated normal as the average concentration of this batch, 290 ppb, was close to the normal concentration of properly treated batches at this location over the past three years.

The amount of mercury discharged from Station 0 under these circumstances was calculated to be:

$$42{,}000 \text{ USG} \times 8.34 \frac{\text{lbs}}{\text{USG}} \times 290 \text{ ppb} = 0.102 \text{ lbs Hg}$$

This was added to the total discharged from Stations 5 and 7 to give a total of 0.136 lbs Hg per day. Again, this figure was within the Federal regulation of 0.155 lbs Hg based on a production of 31 tons per day of chlorine.

Situation 3 - Mercury loading for a day with an abnormal treated effluent batch discharge

In situation 3, again Stations 5, chlor-alkali plant discharge to the lake, and 7, cooling water ditch, were again included with Station 0. In this situation however, the May 17th discharge was designated abnormal as the average concentration of this batch, 4,284 ppb, was considerably above the normal concentration of a properly treated batch.

The amount of mercury discharged from Station 0 was calculated to be:

$$42{,}000 \text{ USG} \times 8.34 \frac{\text{lbs}}{\text{USG}} \times 4{,}284 \text{ ppb} = 1.501 \text{ lbs Hg}$$

This was added to the total discharged from Stations 5 and 7 to give a total of 1.535 lbs. This figure was considerably above the Federal regulation of 0.155 lbs Hg.

Of the three treated wastewater batches discharged at Station 0 during the survey, the May 17th batch was the only abnormal one. However, during the year preceding the survey, a total of 19 batches of varying degrees of abnormality were discharged. This observation was based on data reported to the Ministry of the Environment by American Can on a monthly basis. This represented 12.5% of the batches discharged.

Because of the high number of abnormally treated effluent batch discharges and the amount of mercury being discharged into the lake, the Ministry of the Environment charged American Can with violating the Federal regulation of 0.005 lbs of mercury discharged per ton of chlorine produced on sixteen occasions during the period of August, 1975 to July, 1976. The Company pleaded guilty to the charges and was fined a total of $64,000.

EFFICIENCY OF THE MERCURY WASTEWATER TREATMENT SYSTEM

For a normally treated wastewater batch, it was calculated that 0.102 lbs of mercury were discharged to the lake. The amount of mercury entering the treatment tank (Station 1, chlor-alkali plant sump to treatment tank) was calculated to be:

$$42{,}000 \text{ USG} \times 8.34 \ \frac{\text{lbs}}{\text{USG}} \times 3.083 \text{ ppb} = 1.080 \text{ lbs Hg}$$

Therefore, 1,080 - 0.102 = 0.978 lbs Hg were removed. This represented an efficiency of $\frac{0.978}{1.080} \times 100 = 90.6\%$

MERCURY LOADING IN THE PULP MILL EFFLUENT

Direct discharges from the pulp mill to the lake were sampled and measured at Station 9, alkaline bleachery, Station 10, acid bleachery, and Station 11, main mill effluent.

At Station 9, the amount of mercury discharged daily:

$$= (4{,}000 \times 24 \times 60) \ \frac{\text{USG}}{\text{day}} \times 8.34 \ \frac{\text{lbs}}{\text{USG}} \times 12.4 \text{ ppb} = 0.597 \text{ lbs Hg}$$

At Station 10, the amount of mercury discharged daily:

$$= (5{,}700 \times 24 \times 60) \ \frac{\text{USG}}{\text{day}} \times 8.34 \ \frac{\text{lbs}}{\text{USG}} \times 4.7 \text{ ppb} = 0.322 \text{ lbs Hg}$$

At Station 11, the amount of mercury discharged daily:

$$= (7{,}000 \times 24 \times 60) \ \frac{\text{USG}}{\text{day}} \times 8.34 \ \frac{\text{lbs}}{\text{USG}} \times 4.5 \text{ ppb} = 0.378 \text{ lbs Hg}$$

These added to a total of 1.297 lbs of mercury discharged daily from the pulp mill.

Service water to the pulp mill contained an average of 0.13 ppb mercury. During the survey, this service water flowed to the pulp mill at 16,700 USGPM. Therefore, the amount of mercury in the service water was calculated to be:

$$(16{,}700 \times 24 \times 60) \ \frac{\text{USG}}{\text{day}} \times 8.34 \ \frac{\text{lbs}}{\text{USG}} \times 0.13 \text{ ppb} = 0.026 \text{ lbs Hg}$$

This then would mean a net discharge of mercury from the pulp mill of 1.271 lbs per day.

It was suspected that the major primary sources of mercury to the pulp mill effluent were from the products produced in the chlor-alkali plant for use in the pulp mill. These products included sodium hydroxide (caustic soda), sodium chlorate and sodium hypochlorite. Chlorine, also produced in the chlor-alkali plant for use in the pulp mill, was considered to transport a negligible amount of mercury to the mill.

Caustic Soda

Mercury in caustic soda averaged 139 ppb (Station 3) during the week of the survey. Caustic soda production to the pulp mill averaged 70 tons/day during the week of the survey. The daily loading of mercury in the caustic soda was calculated to be:
140,000 lbs x 139 ppb = 0.019 lbs Hg

As described previously, the caustic soda was filtered to remove impurities including mercury before it left the chlor-alkali plant. This accounted for the low loading.

Sodium Chlorate

Mercury in sodium chlorate averaged 11,400 ppb Hg during the week of the survey. Sodium chlorate production averaged 10.5 tons/day. The daily loading of mercury in the sodium chlorate was calculated to be:
21,000 lbs x 11,400 ppb = 0.239 lbs Hg

Sodium Hypochlorite

Mercury in sodium hypochlorite averaged 2,960 ppb during the week of the survey. Sodium hypochlorite production averaged 120 tons/day. The daily loading of mercury in sodium hypochlorite was calculated to be:
240,000 lbs x 2,960 ppb = 0.710 lbs Hg

The total amount of mercury transported from the chlor-alkali plant to the pulp mill was the sum of the above (0.019 + 0.239 + 0.710). Thus, an estimated 0.968 lbs of mercury was transported daily in the products from the chlor-alkali plant to the pulp mill. This figure is less than the 1.271 lbs of mercury calculated to have been discharged from the pulp mill during the same period. It is believed that this discrepancy may be explained by the fact that the products (caustic soda, sodium chlorate and sodium hypochlorite) were stored in tanks between leaving the chlor-alkali plant and being used in the pulp mill. Mercury sludges build up in these tanks could be inadvertently transferred with the products to the pulp mill. Further sampling at the pulp mill and the chlor-alkali plant on July 21st and 23rd, 1976, indicated that on these dates there appeared to be a carry over. Caustic soda averaged 190 ppb mercury in the chlor-alkali plant, while in the pulp mill bleach plant it averaged 620 ppb mercury.

DISCUSSION OF EFFLUENT SURVEY RESULTS

As noted earlier, the allowable discharge of mercury is based on the daily production of chlorine at the chlor-alkali plant, i.e. 0.005 lbs of mercury discharged per ton of chlorine produced.

During the survey, chlorine production averaged 31 tons per day. This would give an allowable discharge of mercury of 0.155 lbs per day.

It has been shown that on a day with no treated wastewater batch discharge, and also on a day with a normal treated wastewater batch discharge, the chlor-alkali plant was within the regulatory figure. However, on a day with an abnormal treated wastewater batch discharge, the regulatory figure was exceeded.

The total amount of mercury leaving the complex, pulp mill and chlor-alkali plant, on a day with no discharge of treated wastewater, was 1.305 lbs of mercury. On a day with normal treated wastewater, discharge was 1.407 lbs. These discharges 8 to 9 times higher than the regulatory figure for a chlor-alkali plant, occurred because mercury was transferred from the chlor-alkali plant to the pulp mill in products for use in the pulp mill. There are no specific regulations on the amount of mercury in products from a chlor-alkali plant.

Because of the total amount of mercury being discharged from the complex to Lake Superior, the Ministry of the Environment served a Control Order on American Can of Canada Limited which in effect gave the Company the option of completely closing down the mercury cell chlor-alkali operation or converting the operation to a process which did not use mercury. The Company chose to completely close down the mercury cell operation. This was done on August 31st, 1977. As a result of the closure of the chlor-alkali plant, the amount of mercury being discharged from the complex has been substantially reduced.

This survey confirmed the need to eliminate all sources of mercury in the chlor-alkali plant and all storage tanks or other facilities in the plant or pulp mill where mercury sludges or contaminants may have collected. The Company has been required to eliminate these sources in conjunction with the closure of the chlor-alkali plant.

MERCURY IN SOIL AND AIR

OUTLINE AND METHODS

The 1974 and 1975 soil surveys included sample material to a depth of 10 centimetres. In May, 1976, this was extended to 15 cm and additional sampling sites were selected to the south and southwest of the plant area (Figure 3). At the same time, a mobile van provided by Air Resources Branch, Toronto, monitored mercury levels in air downwind of the plant, near the Company's warehouse area, and at two disposal sites used for waste materials (Figure 4). Finally, to assess possible losses of mercury in run-off water from the hill behind the mill, surface drainage water samples were collected periodically between April and July, 1976 (Figure 5).

Ambient air mercury levels were monitored with a "Scrintex" mercury vapour analyzer housed in a van. This instrument was basically an ultra violet spectrophotometer with a detection limit of 0.005 micrograms (μg) per cubic metre (m^3) of air. Analyzer output was recorded on a strip chart and also on punch tape in a data acquisition system. Depending on wind direction and accessibility, monitoring usually began downwind of the source at the point of expected highest pollutant concentration. Measurements were made for periods of at least 30 minutes at each location.

RESULTS

Soil Sampling

Mercury concentrations in soil at the 0-5, 5-10, and 10-15 cm levels are summarized in Table 1. Using a SYMAP program developed by Harvard University, contour maps (Figures 6 to 8) were prepared showing zones of contamination in the mill area. These results confirmed those from 1975. Soil samples usually showed progressively lower mercury concentrations with increasing depth, although there were a few exceptions to this trend (sites 8, 9 and 19). Except for the 5-10 cm value at site 10, there was a pronounced gradient of decreasing mercury levels with increasing distance in all directions from the source. An anomalous value was encountered at site 31, where very high mercury levels were recorded. Results from this location were excluded from the contour maps in Figures 6 to 8. The reason for the unusually high values at site 31 are presently unknown and a separate survey has been undertaken to determine the extent of this "hot-spot" area. At Skin Island (Table 1, site 33), the mercury content of soil was only slightly above background levels.

Assuming that soil with more than one part per million (ppm) mercury was contaminated, the zone of contamination near the chlor-alkali plant and pulp mill extended over an area of about 39 hectares. Using soil density ranges of 1.0 to 1.6 g/cc for 0-5 cm soil (high organic content) and 1.2 to 1.8 g/cc for deeper soil, the calculated estimate of mercury in the 39-hectare contaminated area was 112-179 kg in 0-5 cm soil, 101-151 kg in 5-10 cm soil and 68-102 kg in 10-15 cm soil. For all three soil layers, the total estimated quantity of mercury was 281 to 432 kg (618 to 950 lb.)

At the north end of the Company's warehouse area, about 1,400 metres northeast of the mill, a separate soil survey was conducted to establish the origin of mercury contamination first discovered in an earlier investigation in 1975. Airborne emissions from the chlor-alkali plant had already been ruled out as the cause of elevated mercury in soil near the warehouse. Surface soil (0-5 cm) was analyzed from eight sites and the results were plotted in Figure 7. These indicate that the contamination source was within the warehouse fence line. The part of the warehouse yard immediately adjacent to the survey area is used as a temporary storage site for drums of mercury-laden waste pending burial twice annually at a disposal site outside the town area. Spillage has presumably occurred from time to time, resulting in contamination of nearby soils.

Run-off Water

Sample points for surface run-off water are shown in Figure 5. Mercury concentrations were found to be very low, and ranged from 0.1 to 2.0 ppb (Table 2). Based on these limited results, it appears as though only very small quantities of mercury are being washed into Lake Superior from contaminated snow and soil near the mill.

Coal and Fly Ash

During removal of waste from coal-burning steam plant furnaces, an undetermined amount of fly ash may be blown onto adjacent soils. To assess the potential contribution of this material as a contaminant, samples of both fly ash and coal were submitted for mercury analysis. The highest value obtained for ash was 2.3 ppm mercury and the maximum for coal was 0.45 ppm. Considering that soils near the steam plant area contain over 20 ppm mercury, the contribution from coal burning and ash removal must be considered as very minor.

Air Monitoring

Chlor-alkali plant

During the period May 17-21, 1976, a total of 32 hours, 35 minutes of data were collected on ambient air concentrations of mercury. Monitoring locations are indicated in Figures 10a and 10b, and results are given in Table 3. A small selection of values appear in graphical form in Figures 11 and 12. About a third of the data was obtained from site A. Here, the highest 30-minute average (4.8 $\mu g/m^3$) and peak value (7.0 $\mu g/m^3$) were recorded. The Ontario half-hour standard of 5 $\mu g/m^3$ was not exceeded at any time at site A or at other locations. The highest mercury concentration coincided with the maximum temperature recorded during the survey. This finding was expected and could undoubtedly be ascribed to increasing mercury volatility with higher temperatures. Both average and peak levels of mercury decreased significantly with increasing distance from the chlor-alkali plant. At sites F and G (Figure 10b), concentrations decreased to near normal background levels (< 0.01 $\mu g/m^3$).

Warehouse area

On May 18, air monitoring was carried out briefly at the north end of the Company's warehouse area. Mercury levels just above the ground were significantly above background concentrations, but well below the Ontario standard. Close to stored drums of mercury laden waste, mercury levels up to 1.0 $\mu g/m^3$ were found. Thirty minute averages were not determined.

Clarifier sludge disposal site

At the clarifier waste disposal site, near Marathon airport, only background mercury concentrations were recorded, in the range of 0.02 to 0.08 $\mu g/m^3$. There was no evidence of mercury emissions from the sludge piles.

Mercury waste burial area

Measurements for a period of about one hour were made on May 19 at the site where mercury contaminated waste was buried. At ground level above known burial locations, mercury concentrations were below the minimum detectable level ($< 0.005\ \mu g/m^3$). No measurable values were obtained at any point in the burial area.

DISCUSSION

Mercury content of soils near the American Can plant was found to be generally higher in May, 1976 than in November, 1975. The reason for this difference, which was particularly evident for subsurface soils, is unknown. Based on earlier results, it was anticipated that the May, 1976 investigation would have indicated very low mercury levels at a depth of 10-15 cm, but this was not the case. Further sampling at greater depth has been undertaken recently to define the level and extent of subsurface contamination. The fate of mercury in soils is also unknown. The low concentrations in local run-off water suggests that much of the mercury may evaporate to atmosphere.

Contamination of soil at the warehouse area appears to be very localized. Although removal of this contaminated soil does not appear to be warranted, greater care in handling mercury-laden waste should be encouraged to avoid further spillage.

Ambient air concentrations of mercury approached, but did not exceed, the Ontario standard near the chlor-alkali plant. Two factors contributed to depress the average values recorded: generally low air temperatures and wind conditions unfavourable for downwind monitoring. The van was not in the center of the chemical plant plume for intervals longer than a few minutes and, as a result, the 30-minute averages tended to reflect plume-edge rather than plume-center conditions. As a result of the chlor-alkali plant closure, no further monitoring can be carried out.

EFFECT OF MERCURY ON PENINSULA HARBOUR

SURVEY OUTLINE AND METHODS

During September, 1975 and May and September, 1976, fish were collected from three locations in Peninsula Harbour (Figure 13). Bottom fauna and sediment collections were obtained during August, 1976 (Figures 14 and 15). In addition to these programs, water samples were collected from four stations within Jellicoe Cove during May, 1976 in conjunction with a survey of mill wastewaters (Figure 16).

Fish Sampling

Fish were collected from Yser Point, Neuve Chapelle Point and Meaux Shoal in close proximity to Skin Island (Figure 13). Collections were made using gill nets with mesh sizes ranging from 3.8 to 11.4 centimetres (1½-4½ inches) and ranging in lengths from 45 to 76 metres (150-250 feet). Nets were normally set within ten metres off shore for periods of not less than twelve hours; usually overnight. Details of net settings are provided in Appendix A.

Fish were removed from the net after capture, identified, counted, weighed and the length was measured prior to removal of flesh from the caudal peduncle area for mercury analysis. Samples were then placed in sterile plastic bags, labelled and chilled until they could be frozen prior to shipment to the Ontario Ministry of the Environment Laboratories, Environmental Trace Contaminants Section, Toronto.

Bottom Fauna

From August 5 to 12, 1976, bottom fauna samples were collected at 62 sites in Peninsula Harbour and in the open waters of Lake Superior, south of The Peninsula (Figure 14). Samples were obtained using a ponar dredge and hand winch, after which the contents were emptied into a box screen, washed through a .065 cm (.0256 inches) sieve; the organisms being separated from the extraneous material and placed into vials containing ninety-five percent ethyl alcohol.

After preservation, the samples were stored for later identification and enumeration.

The locations of transects and sampling sites were as near as possible to those used during the 1969 survey. Due to time and weather restraints, total duplication of the earlier sampling was incomplete.

Water

Water samples were collected from four stations; 170, 250, 400 and 900 metres respectively from the outfall in Jellicoe Cove. Samples were collected from two depths at each station (near the surface and 1 metre above bottom) using a four litre Kemmerer sampler. Samples were preserved with nitric acid and kept refrigerated until analyzed in Toronto (3).

Sediments

Sediments were collected from some of the stations established in 1970 (Figure 15) as well as from the near shore waters of Jellicoe Cove. Samples were obtained from the top 7.6 centimetres of sediment obtained by ponar dredge during bottom fauna collections, except for those samples obtained in Jellicoe Cove, which were collected solely for that purpose. Samples were then sent to Toronto for analysis of mercury concentration.

FINDINGS AND DISCUSSIONS

Fish Sampling

During 1975 and 1976, a total of 149 fish were captured from three locations: Neuve Chapelle Point, Yser Point and Meaux Shoal - Skin Island (Table 4). The least number of fish was collected at Meaux Shoal - Skin Island, an area where one would normally expect to find fish. Fish may tend to avoid this area due to impaired water quality in close proximity to the outfall from American Can of Canada Ltd.

The species captured included (lake trout, _Salvelinus namaycush_; rainbow trout, _Salmo gairdneri_; whitefish, _Coregonus clupeaformis_; longnose sucker, _Catostomus catostomus_; burbot, _Lota lota_; gizzard shad, _Dorosoma cepedianum_; white sucker, _Catostomus comersonii_; and pike, _Esox lucius_. Lake trout, whitefish and longnose sucker were the species most frequently captured, thus providing sample sizes suitable for statistical analysis. Individual fish details are shown in Appendix A.

Originally, it was thought that the three specific sites would show significant differences in fish mercury concentrations; however, little difference was noted. Therefore, results from the three sites were averaged as a single data set and are depicted in Table 5 as mean concentrations for the years 1975 and 1976. As is apparent, there is no difference between the two years; however, mean values are well in excess of the recommended criterion of 0.5 µg/g as set out by the Food and Drug Directorate of the Department of National Health and Welfare.

In evaluating the significance of the value of 0.5, it must be remembered that this criterion was developed for fish offered for sale using assumptions which may not be applicable to sport fishermen who may fish these waters. Table 6 presents the percentage of fish of each of the three major species caught which contained mercury concentrations greater than .5 and 1.0 µg/g.

Of the three major species caught during the survey, lake trout in all cases exceeded the recommended criterion of 0.5 µg/g. The increase from sixty-four percent in 1975 to eighty-four percent in 1976 of the total catch exceeding 0.5 µg/g is probably due to the greater number of trout caught than other species in 1976.

When comparing Peninsula Harbour data for mercury concentrations in fish sizes with similar data collected from other areas along the north shore (Table 7) during the years 1973 through 1976, it is apparent that Peninsula Harbour values are notably greater in most size classes than any of the other areas. Analysis of variance indicates that these values at Peninsula Harbour are significantly higher than for other areas in Lake Superior ($p = .01$). The only area which approaches the levels encountered in Peninsula Harbour is Thunder Bay; a body of water known to have received inputs of mercury.

In areas where no known industrial process is the source, mercury is thought to come from weathering natural mercury-rich geological deposits. Possibly in some areas, drainage from abandoned mining activities (which had mercury indigenous to the tailings or used mercury in the amalgamation of gold and silver) may contribute to mercury uptake by fish. However, in the absence of such sources at Peninsula Harbour, the elevated levels associated with fish caught there must be partially due to the discharges of mercury from American Can of Canada Limited; associated with the production of chlorine and caustic soda.

Bottom Fauna

Analysis results of macroinvertebrates collected are presented in Appendix B.

Fifteen taxa of bottom fauna were identified from the samples collected in Peninsula Harbour. The sludge worm class, Oligochaeta, was found to be the predominant taxon from samples in Peninsula Harbour, followed by true midge larvae and the amphipod, *Pontoporeia affinis*. The isopod, *Asellus militaris* and fingernail clams, *Pisidium spp.* also were present in significant numbers. Distribution of the remaining taxa was too sporadic to be of significance in the interpretation of water quality.

Four taxa of macroinvertebrates were identified from the samples collected in Lake Superior. The dominant species found were: the amphipod, *Pontoporeia affinis*; sludge worms, class Oligochaeta; and true midge larvae. The only other taxon encountered in significant numbers was the isopod, *Asellus militaris*. At no stations were *Pisidium spp.* encountered.

Sample locations in Peninsula Harbour are provided in Figure 15. It was interesting to note that sludge worms occurred in all but three of the thirty-five samples collected within the harbour. The percent frequency of occurrence or population density at each transect, showed some relationship with distance from the source of wastes from American Can of Canada Limited. Most of the transects within the confines of the harbour indicated large populations of sludge worms, which made up the majority of individuals found. The amphipod, *Pontoporeia affinis* did not occur at all sample sites, but did show a relationship between depths of samples and numbers found. This relationship is evident in Figure 17 which depicts a positive correlation between depth at which samples were obtained and the number of Pontoporeia affinis found. However, this contradicts the findings of Freitag, et al (1976) (4) who indicated a negative correlation with depth of Pontoporeia in Lake Superior. This discrepancy may be explained when evaluating the depths from which the collections were made in the two surveys. The samples collected from the Peninsula Harbour survey were obtained from depths of less than 40 metres, whereas the work undertaken by Freitag was done in water considerably deeper, in many cases exceeding 200 metres. This difference in correlation is consistant with Eddy (1943) (5) who observed that on exposed shores, especially to the North and Northwest, "... practically no organisms were found until a depth of eight to ten feet (sic) was reached", and that the profundal fauna, which included Pontoporeia, were "very abundant" between 30 and 60 metres and became progressively less dense to about 275 metres. This phenomenon would account for the positive correlation encountered in the Peninsula Harbour survey. However, the influence of the two industrial plumes from American Can of Canada Ltd. would also account for the reduced numbers of organisms (specifically Pontoporeia) in the littoral regions of Peninsula Harbour and Lake Superior in the vicinity of Marathon; resulting in greater numbers of Pontoporeia being encountered at greater depths of up to 35 metres.

Densities of true midge larvae give some indication as to the organic wastes present at five of the transects, which had substrates and sediments consisting of bark and wood fibre. Areas of Beatty Cove and Jellicoe Cove in the past have been used for pulp wood storage in booms and the latter cove is the immediate receiver for wastes emanating from the mill. The isopod, Asellus militaris, tends to follow the same pattern showing increased numbers where bark and wood chips have accumulated in the natural substrate surface.

The remainder of the taxa encountered were randomly scattered throughout the area sampled, indicating no particular pattern of occurrence or population density.

Sample sites from transects on Lake Superior are provided in Figure 14.

It is difficult to assess to what degree the wastes may have affected the fauna in this area of Lake Superior. Amphipods (Pontoporeia affinis) constitute the majority of individual organisms collected at sample sites on transect R, U and V; increasing in numbers with depth of sample. Although data are incomplete, there is an elevated number of Oligochaetes in the vicinity of the main outfall. The sludge worm population indicated increasing numbers at transects R and U with increasing distance from the waste outfall and with increasing depth. The numbers of fauna found and the limited taxa diversity suggest that toxic conditions may exist in the near-shore waters in the vicinity of the main outfall. Substrate type and wave action in the area may be a determining factor on the impoverished populations and diversity of fauna. Wave action, however, would not explain the low standing crop of amphipods that would be expected in the deep water stations.

In summary, the presence of sludge worms, true midge larvae and the isopod, Asellus militaris, indicates an organic buildup in the waters of Beatty and Jellicoe Coves (bark, wood chips and fibre associated with the booming and pulping of wood).

The possible influence on the distribution and numbers of the amphipod, Pontoporeia affinis, is significant because this species is a preferred fish food in the cold deep waters of Lake Superior. The sporadic occurrence of other invertebrates which are characteristic of other north shore pristine waters suggests that the wastes have little impact on the benthic communities except in the immediate vicinity of the two outfalls.

It should be emphasized that the disruptions found in the benthic communities of Jellicoe Cove, Beatty Cove and the area south of The Peninsula, are due primarily to the dissolved organic materials and suspended solids discharged or deposited in these areas and not to the mercury discharges suggested by the title. However, this does not suggest that mercury is not disrupting communities in some lethal or sublethal manner.

The numbers of organisms collected in 1976 were dramatically reduced from those taken in 1969, and the zones of impact less clearly defined.

Though not part of the actual bottom fauna documentation, the presence of Cladophora (a filamentous alga) was noted south of the main outfall from American Can of Canada Ltd. and is suggestive of enriched conditions.

Water and Sediments

Associated with the chemical plant at American Can of Canada Limited are discharges bearing mercury used in the production of chlorine and caustic soda. Since May, 1972, 7,090 kilograms (1.9 x 10^4 lbs) of mercury have been lost to terrain and the receiving waters, Peninsula Harbour and Lake Superior (6).

Samples of water were collected from four stations in Jellicoe Cove (Figure 16) and the underlying sediments to determine whether methyl mercury was actively being produced in the Bay. Table 8 depicts the levels of methyl mercury found in the water within Peninsula Harbour at various distances from the outfall at various depths. Inplant and discharge monitoring has been undertaken by the Industrial Abatement Section of this Ministry and has been reported elsewhere in this report.

The analytical capability to measure methyl mercury in waters at levels in the parts per trillion (ng/l) range has been developed and made available only in recent years; consequently, previous analysis has always indicated levels below the detection limit.

It is apparent from Table 8 that methyl mercury is being actively produced in the sediments of Jellicoe Cove and being released to the overlying waters. The higher levels in the water are concomitant with the higher levels detected in the sediment related to distance from the outfall. The level of methyl mercury nearer the surface tends to be reduced because of the photosensitivity of methyl mercury and it's displacement from the sediments. Currents and/or outfall turbulence would account for the near equal values detected at both depths of Station 1, 170 metres from the outfall. Figure 18 suggests that the accumulative effect of mercury laden discharges associated with the kraft mill industry, is significant in terms of mercury levels in the sediments of Jellicoe Cove. The configuration of the isopleths of mercury concentration in sediments in a northwesterly direction from the outfall suggests that settlement of mercury is depth related (Figure 19). Currents in the harbour may also be instrumental in causing dispersal of sediments in a northwesterly direction. This pattern is compatible with the knowledge that mercury in paper mill effluents is normally tied-up with fine organic particles (7).

Table 6 indicates mercury concentrations in the sediments of other areas of Peninsula Harbour and the near-shore waters of Lake Superior, south of The Peninsula (Figure 15). Some stations where sediments were taken are comparable to stations previously established in 1970. These results are also presented for comparative purposes in Table 9. Generally, it can be said that high concentrations of mercury can be found in the immediate vicinity of the outfall in Jellicoe Cove, and diminish as the distance from the outfall increases.

Sediments on the Lake Superior side of The Peninsula have low mercury concentrations, apparently at or close to background.

AQUATIC ENVIRONMENT SUMMARY

The aquatic environment in the vicinity of the kraft mill and chemical plant of American Can of Canada Limited at Marathon, is still and will continue to be adversely affected by the wastes emanating from this industrial complex until adequate treatment of wastes is obtained. Additionally, previously discharged wastes will continue to have an influence on biological communities for many years.

As previously reported in 1972, and further substantiated by this report, mercury concentrations in fish continue to be above the acceptable level of 0.5 micrograms per gram (µg/g) as set out by the Food and Drug Directorate of the Department of National Health and Welfare in 1971. All lake trout captured in Peninsula Harbour during 1975 and 1976 contained levels in excess of 0.5 µg/g, thirty-eight percent of which were above 1.0 µg/g.

Mercury levels in sediment in the immediate vicinity of the outfall and Jellicoe Cove reached levels as high as 112 µg/g and diminished as distance from the discharge increased. However, at distances in excess of 500 metres, concentrations still exceeded background levels of Lake Superior.

Preliminary analysis of water in Jellicoe Cove suggests a similar pattern of methyl mercury concentration decreasing with increasing distance from the mill outfall; associated with the methylation of mercury in the sediments.

Biological evaluations in the sediments of the adjacent waters suggest severe pollution of the sediment concomitant with the wastes discharged from the mill and chemical plant. However, this is not solely attributed to mercury, but primarily to BOD and suspended solids.

The work conducted in 1975 and 1976 supports earlier work done by this Ministry in defining elevated levels of mercury in fish and sediment, and disruption of bottom fauna communities. Little or no improvement in the quality of the aquatic environment of Peninsula Harbour has occurred since the earlier study in 1969.

ACKNOWLEDGEMENTS

Contributions and assistance from the following agencies is gratefully acknowledged:

- Regional Laboratory, Northwestern Region, for mercury analysis of all samples and the collection of samples
- Inorganic Trace Contaminants Section, Laboratory Services Branch, for mercury analysis of samples and the collection of samples
- Phytotoxicology Section, Air Resources Branch, for processing soil samples
- Instrumentation Development and Monitoring Unit, Technology Development and Appraisal Section, Air Resources Branch, for conducting the air quality survey
- Marathon High School, for the use of their facilities

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TABLE 1. Concentrations of mercury (ppm, dry weight) in soils near American Can of Canada Ltd., Marathon, May 17-19, 1976.

Site	Distance (metres) and direction from source*	Mercury in soil at depths of		
		0-5 cm	5-10 cm	10-15 cm
1	510 NW	2.3	1.9	0.8
2	375 NW	3.6	2.9	2.9
3	410 NW	0.3	0.1	< 0.1
4	250 NW	7.3	7.0	4.0
5	280 WNW	4.6	2.5	0.7
6	130 WNW	13.6	11.0	5.9
7	175 W	6.6	5.8	3.7
8	250 W	3.1	5.2	0.8
9	50 SW	22.3	6.8	10.8
10	140 SW	10.3	8.8	8.5
11	225 SW	8.8	7.0	3.6
12	395 SW	1.8	0.7	0.4
13	145 S	35.7	32.0	21.0
14	200 S	18.3	14.0	12.6
15	275 SSW	7.6	7.1	2.4
16	430 SW	2.9	2.4	0.4
17	600 SW	2.0	0.9	0.6
18	275 SSE	0.8	0.5	0.4
19	320 S	1.7	2.0	1.7
20	380 S	3.7	2.7	1.6
21	515 SSW	2.8	1.6	0.6
22	670 SSW	2.2	2.1	0.8
23	725 E	0.1	< 0.1	< 0.1
24	300 SE	1.0	0.8	0.6
25	400 SE	1.5	1.3	0.6
26	435 SSE	2.4	1.4	0.8
27	550 S	1.4	0.9	0.5
28	675 SSW	1.0	0.8	0.8
29	450 SE	0.8	0.7	0.2
30	525 SSE	1.2	0.3	0.1
31	625 S	47.5	22.0	6.1
32	710 SSE	0.8	< 0.1	< 0.1
33	930 N	1.1	0.5	0.2
34 (control)	2500 NE	< 0.1	< 0.1	< 0.1
35 (control)	5400 NE	< 0.1	< 0.1	< 0.1

*Arbitrarily designated as centre of south wall of chlor-alkali plant.

TABLE 2. Mercury content (ppb) in surface run-off water near American Can, Marathon, 1976.

Location	Date	Samples collected by: American Can	Samples collected by: Ministry of Environment
A	April 5	9.0	
	6	2.0	
	8	2.0	2.0
B	July 27		0.4
C	April 5	7.0	2.0
	6	4.0	
	8	3.0	
	23	2.0	
	May 5	4.0	
	14	1.0	
D	April 5	1.0	
	6	<1.0	
	8	<1.0	
	July 27		0.1
E	April 5	6.0	
	6	2.0	0.2

TABLE 3. Atmospheric mercury concentrations monitored in the vicinity of American Can of Canada Ltd., May, 1976.

			Concentrations ($\mu g/m^3$)			
			30-min.averages		Peaks	
Site	Date	Period monitored	Min.	Max.	Min.	Max.
A	17	15:50 - 16:46	0.22	0.30	0.08	0.77
		16:47 - 17:49	0.26	0.29	0.08	0.68
		18:07 - 19:01	0.43	0.56	0.12	1.28
	18	8:20 - 9:21	1.40	2.10	0.05	3.28
	20	17:43 - 18:14	4.80	4.80	2.26	7.04
	21	8:20 - 9:23	0.85	1.00	0.09	2.89
		10:00 - 11:07	0.74	1.10	0.07	3.01
		14:30 - 15:02	0.48	0.50	<0.01	1.39
		15:32 - 18:37	0.86	1.90	<0.01	5.19
		18:43 - 20:26	0.83	1.80	0.15	4.03
B_1	19	16:08 - 16:42	0.02	0.02	<0.01	0.23
B_2	20	11:25 - 11:57	0.69	0.70	0.26	1.61
		15:15 - 16:16	1.80	2.10	0.17	5.32
B_3	20	12:15 - 13:06	1.20	1.40	0.32	3.04
C	17	9:40 - 10:12	0.05	0.05	0.01	0.10
		11:00 - 11:45	0.06	0.07	0.02	0.19
		12:00 - 12:36	0.13	0.13	0.02	0.28
		14:10 - 15:28	0.07	0.12	0.04	0.36
		19:27 - 20:28	0.19	0.25	0.08	0.61
	18	17:55 - 20:29	0.28	0.72	0.06	1.99
	20	20:10 - 21:01	0.44	0.67	<0.01	1.98
D	18	12:30 - 15:32	0.02	0.11	<0.01	0.29
		16:10 - 16:50	0.08	0.09	0.03	0.36
	19	8:50 - 9:50	0.08	0.24	0.06	0.50
	21	12:40 - 14:20	0.09	0.26	<0.01	0.61
E	20	17:00 - 17:30	0.07	0.07	<0.01	0.36
		18:20 - 19:21	0.21	0.57	0.01	1.56
F	20	13:15 - 14:06	<0.01	<0.01	<0.01	0.01
		14:10 - 14:55	<0.01	0.02	<0.01	0.17
G	19	13:18 - 13:48	<0.01	<0.01	<0.01	0.02
		14:20 - 14:51	<0.01	<0.01	<0.01	<0.01
		17:10 - 18:32	<0.01	<0.01	<0.01	<0.01
	20	9:36 - 10:10	<0.01	<0.01	<0.01	0.01

TABLE 4: Total Number of Fish Caught at Three Locations During 1975-76 in Peninsula Harbour, Lake Superior.

	Sept. 1975	May 1976	Sept. 1976	Total
Neuve Chapelle Point	41	1	44	86
Meaux Shoal	3	4	12	19
Yser Point	20	4	20	44
TOTAL	64	9	76	149

The above totals include all fish captured.

TABLE 5: Summary of Mean Mercury Concentrations in Three Species of Fish in Peninsula Harbour, Lake Superior, 1975 and 1976.

		Number of Fish	Mean Hg µg/g	σ
LAKE TROUT				
	1975	6	1.00	0.56
	1976	33	1.12	0.73
WHITEFISH				
	1975	15	0.74	0.33
	1976	18	0.86	0.62
LONGNOSE SUCKER				
	1975	26	0.81	0.65
	1976	24	0.85	0.59

TABLE 6: Numbers and Percentages of Three Species of Fish in Peninsula Harbour, Lake Superior, Exceeding Selected Criteria During 1975 and 1976.

	No. of Fish	%>0.5 µg/g	%>1.0
1975 Data (From 3 sampling points)			
Lake Trout	6	100% (6)	33% (2)
Whitefish	15	73% (11)	13% (2)
Longnose Sucker	26	54% (14)	35% (9)
TOTAL	47	64% (30)	28% (13)
1976 Data (From 3 sampling points)			
Lake Trout	33	100% (33)	39% (13)
Whitefish	18	67% (12)	33% (6)
Longnose Sucker	24	75% (18)	21% (5)
TOTAL	75	84% (63)	32% (24)

TABLE 7: Mean Mercury Concentrations in Eight Size Classes of Fish Collected From Lake Superior At Various Points in the Years 1973-76, Values in μg/g.

		SIZE CLASS*							
		1	2	3	4	5	6	7	8
PINE BAY									
1973	LT				.39	.39			
	WF				.09	.19	.29		
THUNDER BAY									
1973	LT					.69	.67	.72	
	WF				.10	.14			
1975	LT					.47	.70		
	WF				.08				
	LS	.20	.16	.29	.75	.93			
1976	LT				.34	.43	.67	.87	
BLACK BAY									
1973	LT					.48	.67	.57	
	WF				.04	.05			
NIPIGON BAY									
1973	WF				.07				
ROSSPORT POINT									
1973	LT				.07	.38			
	WF				.18	.28			
1975	WF			.08	.09				
	LS				.15	.28			
1976	LT					.53	.48		
JACKFISH BAY									
1973	LT					.46			
	WF				.06				
PENINSULA HARBOUR									
1973	LT					.70	.58		
	WF				.67	1.00			
1975	LT						1.34	.84	
	WF		.59	.57	.76				
	LS		.41	.35	1.10	1.94			
1976	LT						1.10	.94	.82
	WF			.63	.91				
	LS	.51	.70	.40	1.56	1.90			

TABLE 7: Cont'd

		SIZE CLASS*							
		1	2	3	4	5	6	7	8
MICHIPICOTEN BAY									
1973	LT				.69				
	WF				.17	.17			
BATCHAWANA BAY									
1973	LT					.44	.43		
	WF				.15	.13			

*SIZE CLASS

1	20.32-25.40 cm
2	25.40-30.48 cm
3	30.48-35.56 cm
4	35.56-45.72 cm
5	45.72-55.88 cm
6	55.88-66.04 cm
7	66.04-76.20 cm
8	76.20- cm

LT - Lake Trout
WF - Whitefish
LS - Longnose Sucker

TABLE 8: Mercury Concentrations in Water From Four Stations Within Peninsula Harbour, August, 1976. Values in ng/l.

Station	Depth (m)	Hg (ng/l)
1	6.1	3.8
	12.2	4.0
2	3.6	1.3
	6.1	3.2
3	2.7	< .5
	3.4	5.4
4	7.6	< .5
	15.2	< .5

Properties of Underlying Sediments

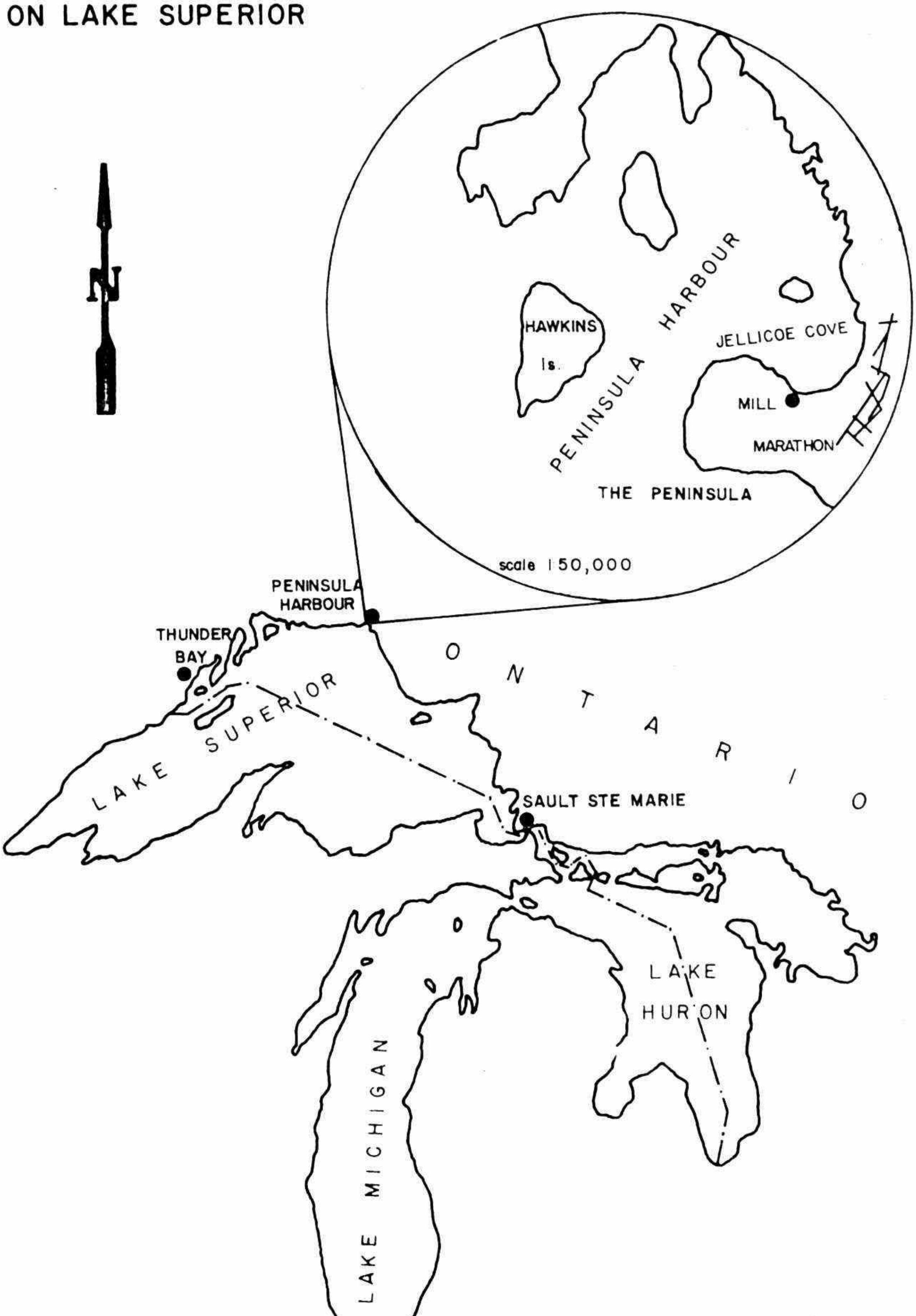
Station 1	170 metres from outfall, depth - 12.8 metres - sediment - fine sand and wood fibre; total Hg - 45 µg/kg, methyl Hg - 2.9 µg/kg, LOI - 7.3%
Station 2	250 metres from outfall, depth - 7.3 metres - sediment - fine sand and wood fibre; total Hg - 2.7 µg/kg, methyl Hg - 4.4 µg/kg, LOI - 3.2%
Station 3	400 metres from outfall, depth - 3.7 metres - sediment - wood chips, fibres and medium grained sand; total Hg - 1.8 µg/kg, methyl Hg 7.7 µg/kg, LOI 70%
Station 4	50 metres from southwest shore of Skin Island - depth- 16.8 metres - sediment - fine clay; total Hg - .04 µg/kg, methyl Hg - < 1 µg/kg, LOI 4.5

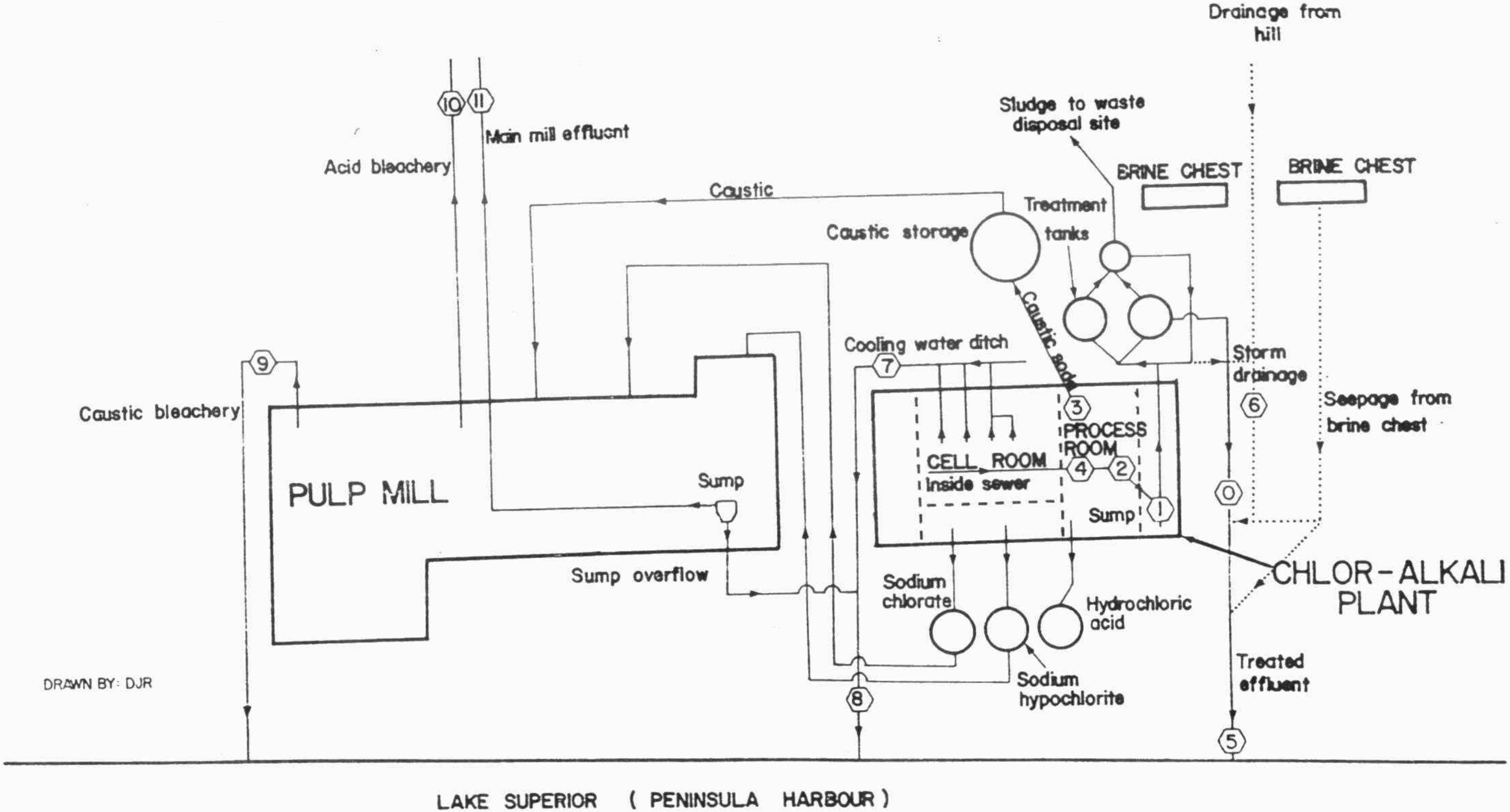
TABLE 9: Mercury Levels in Lake Superior and Peninsula Harbour Sediments, 1976 Survey (top 7.5 cm)

Station	Hg (μg/g)
E2	0.18
E5 (30)	8.20 (11.00)
F1	0.27
G2 (12)	6.10 (7.40)
G5	4.30
H2	2.60
I2	0.03
M2	1.70
N2 (28)	4.50 (3.50)
O2	2.40
P2	3.20
R1	0.08
S2 (46)	0.08 (.17)
T1	0.73
U2 (44)	0.10 (.12)
U5	0.02
V1	0.08
V4	0.04
V7	0.01
V10	0.01

Information for corresponding stations of the 1970 survey is shown in brackets.

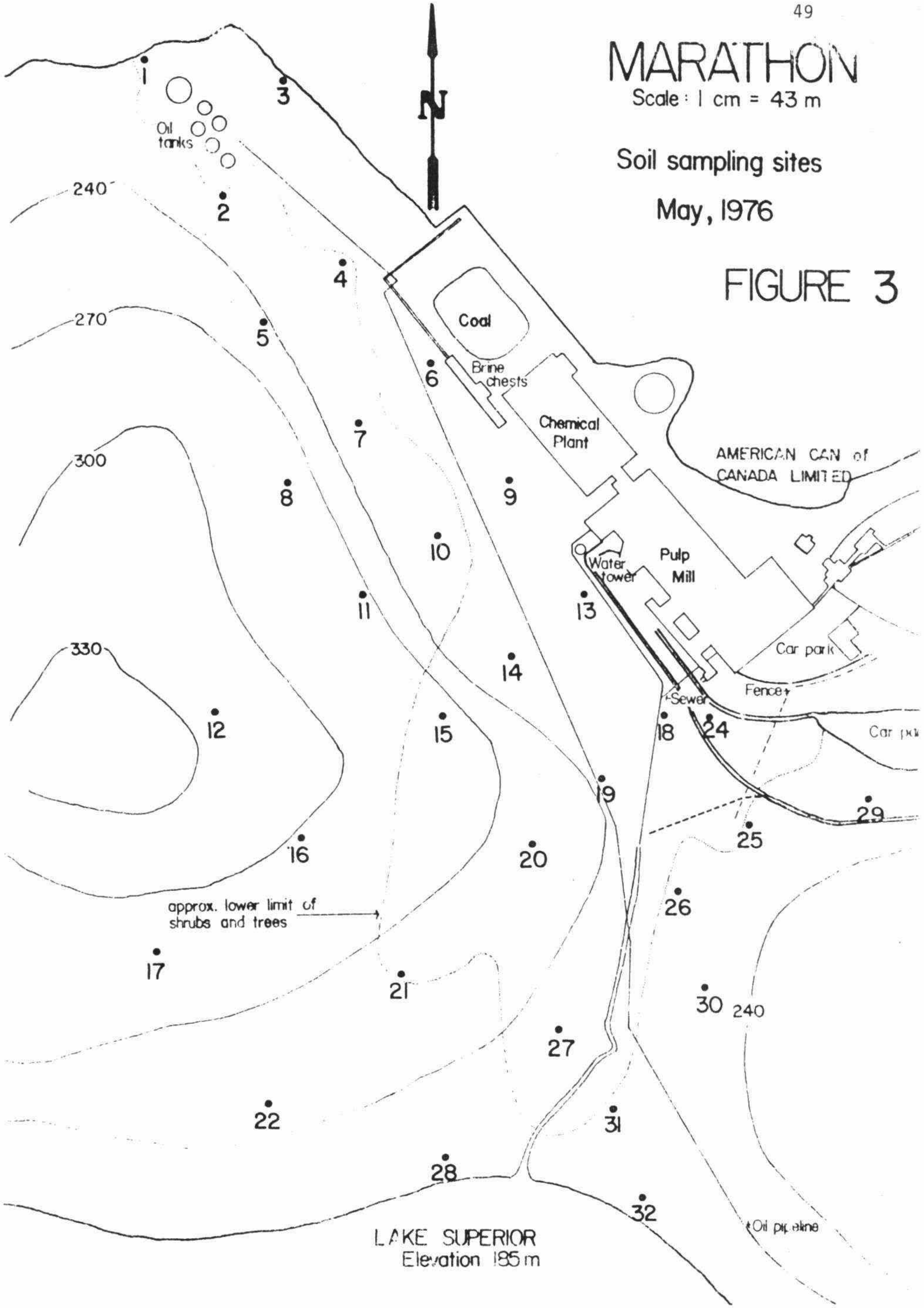
FIGURE 1
LOCATION OF PENINSULA HARBOUR
ON LAKE SUPERIOR





AMERICAN CAN OF CANADA LIMITED - PULP MILL AND CHEMICAL PLANT

FIGURE 2



MARATHON
Scale : 1 cm = 43 m

Soil sampling sites

May, 1976

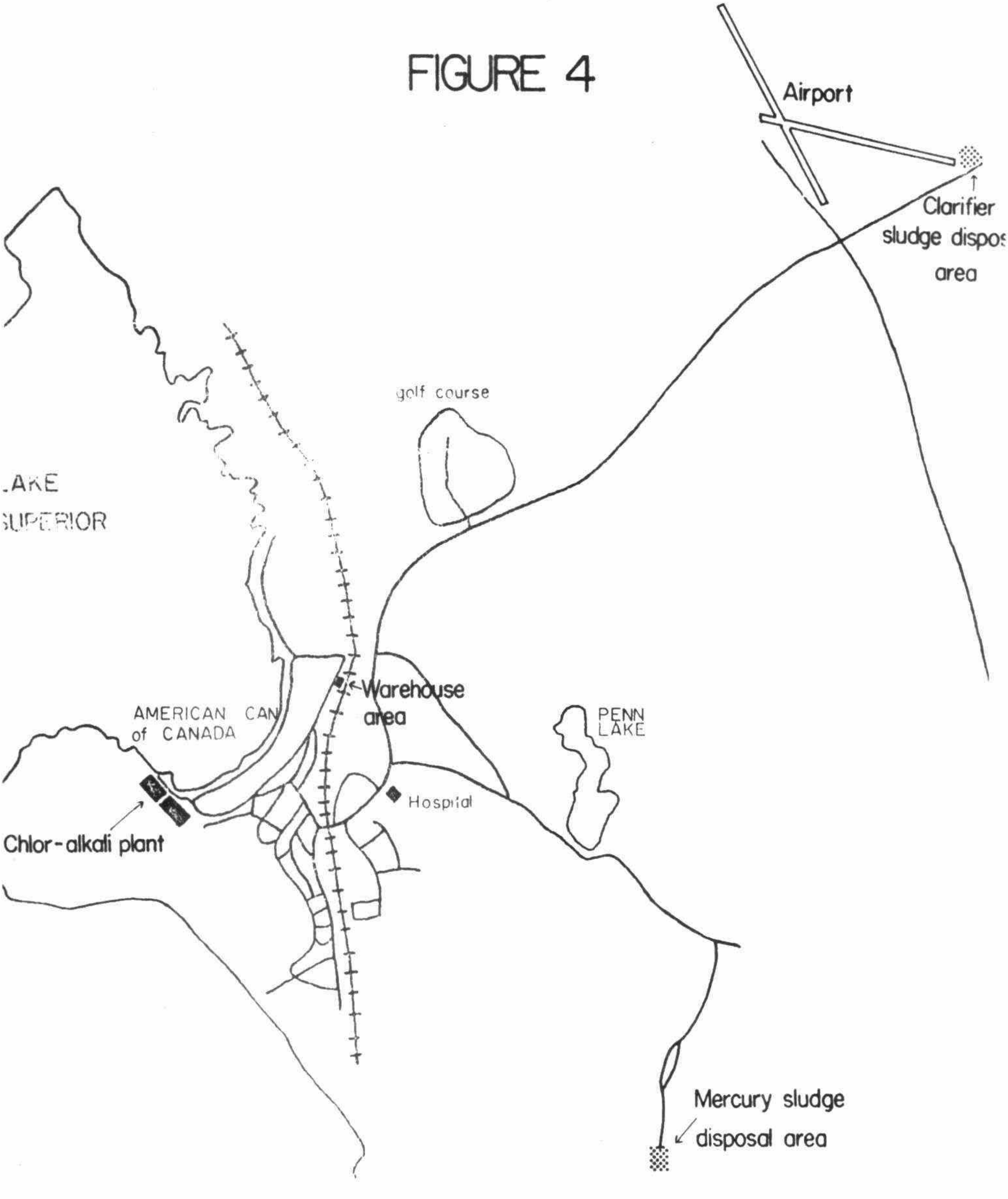
FIGURE 3

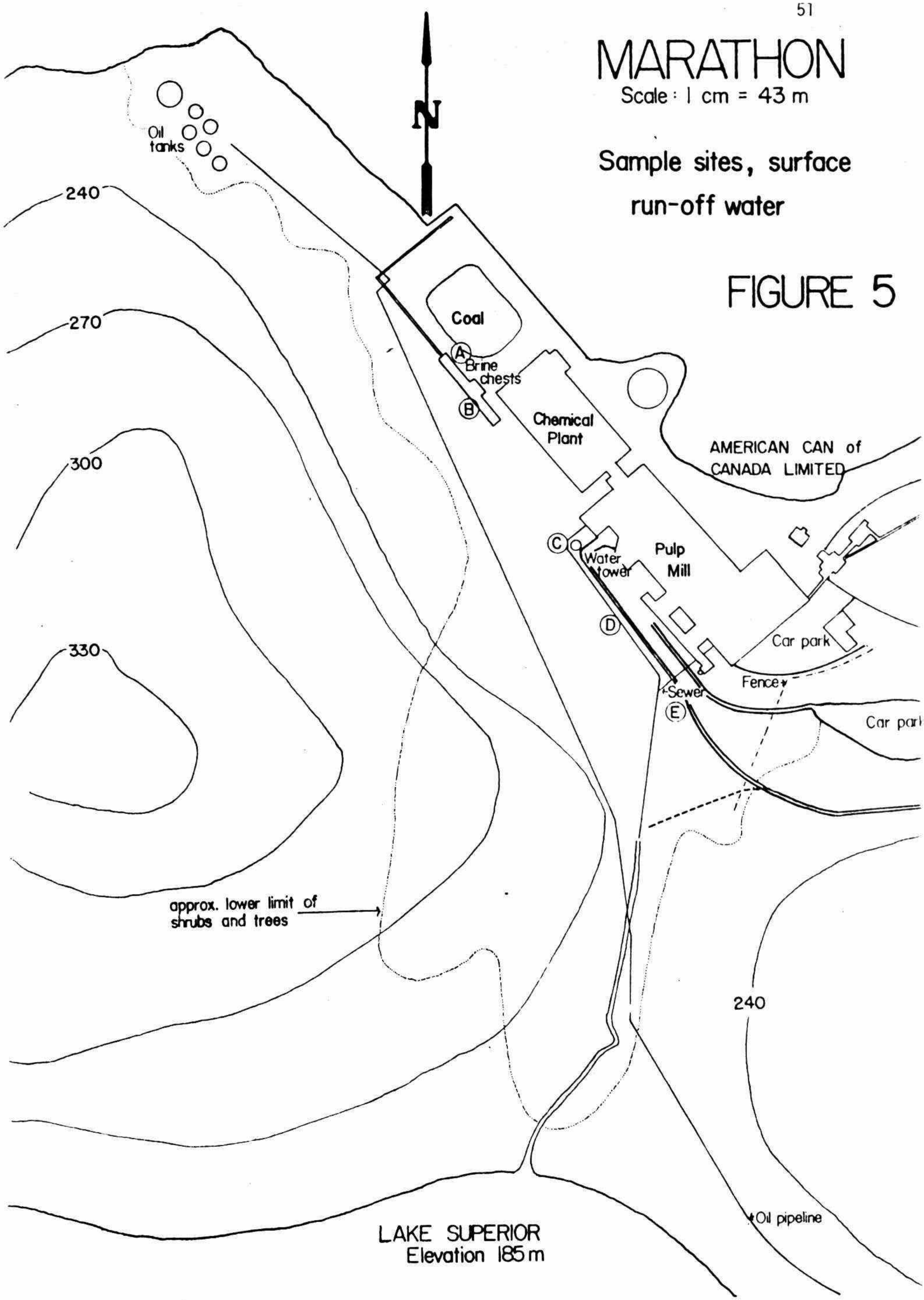
MARATHON

Scale: 1 cm = 317 m

Survey areas, atmospheric mercury levels.

FIGURE 4

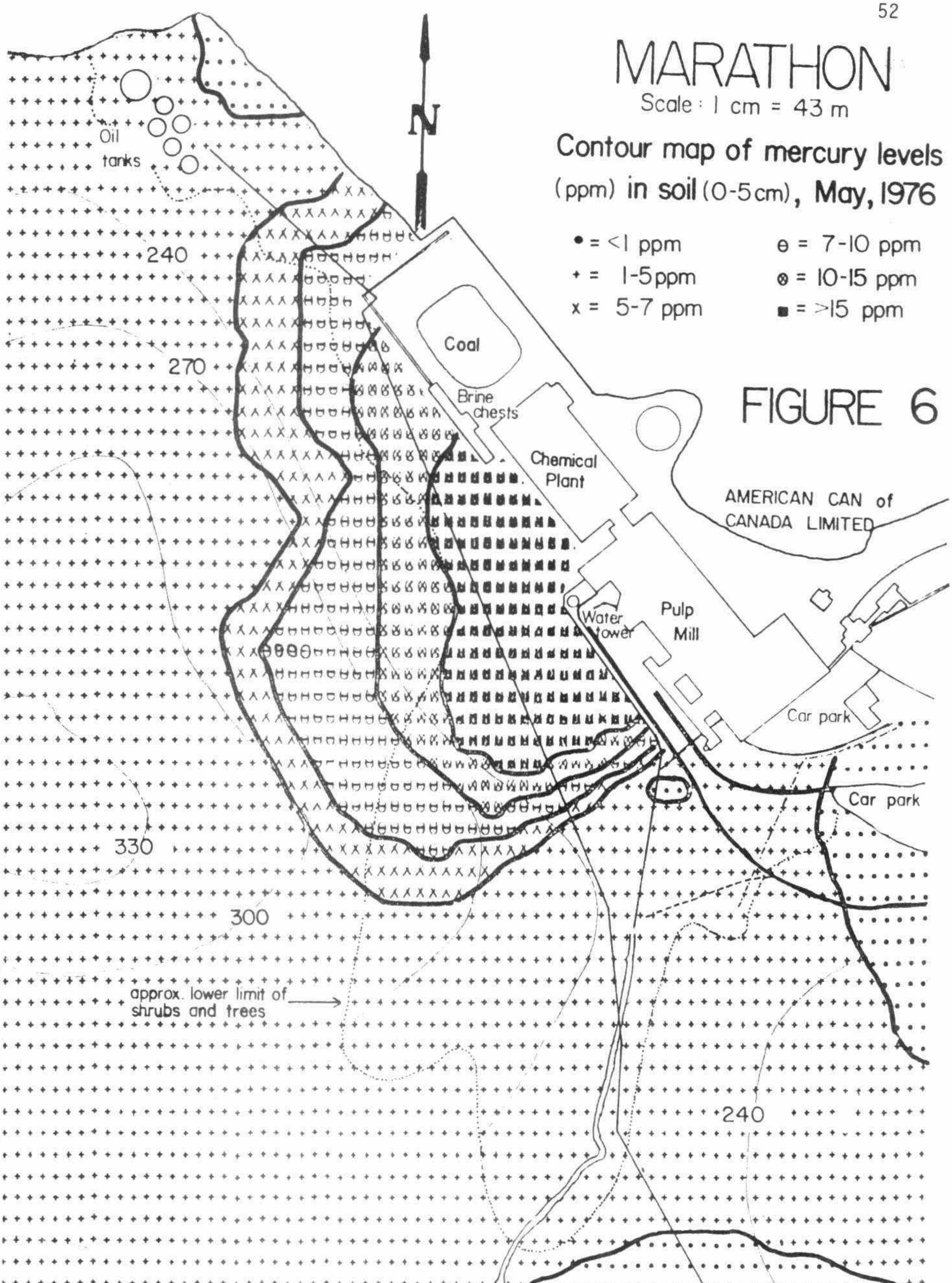




MARATHON
Scale : 1 cm = 43 m

Sample sites, surface run-off water

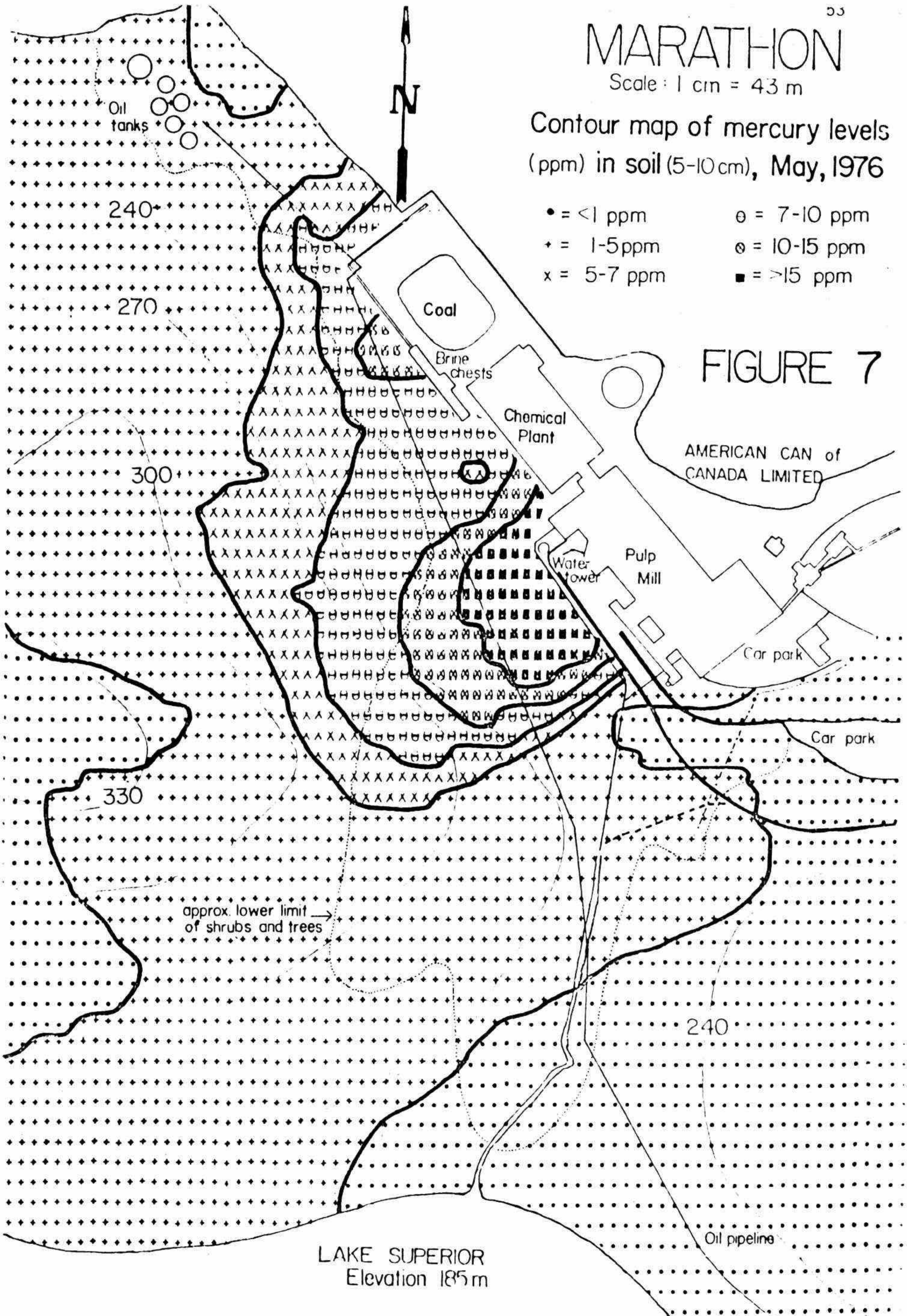
FIGURE 5



MARATHON
Scale : 1 cm = 43 m

Contour map of mercury levels (ppm) in soil (0-5 cm), May, 1976

FIGURE 6

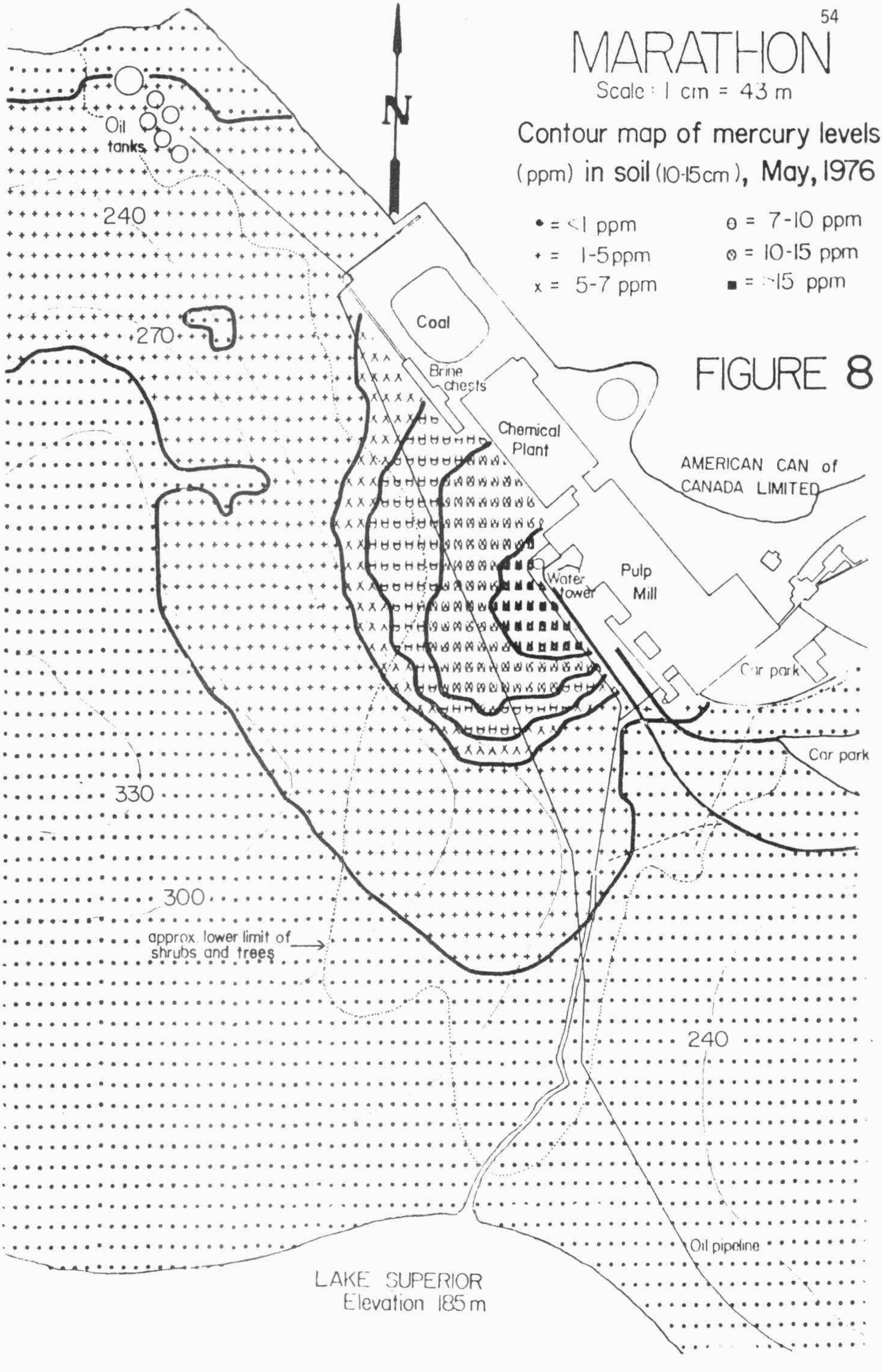


MARATHON

Scale: 1 cm = 43 m

Contour map of mercury levels (ppm) in soil (5-10 cm), May, 1976

FIGURE 7



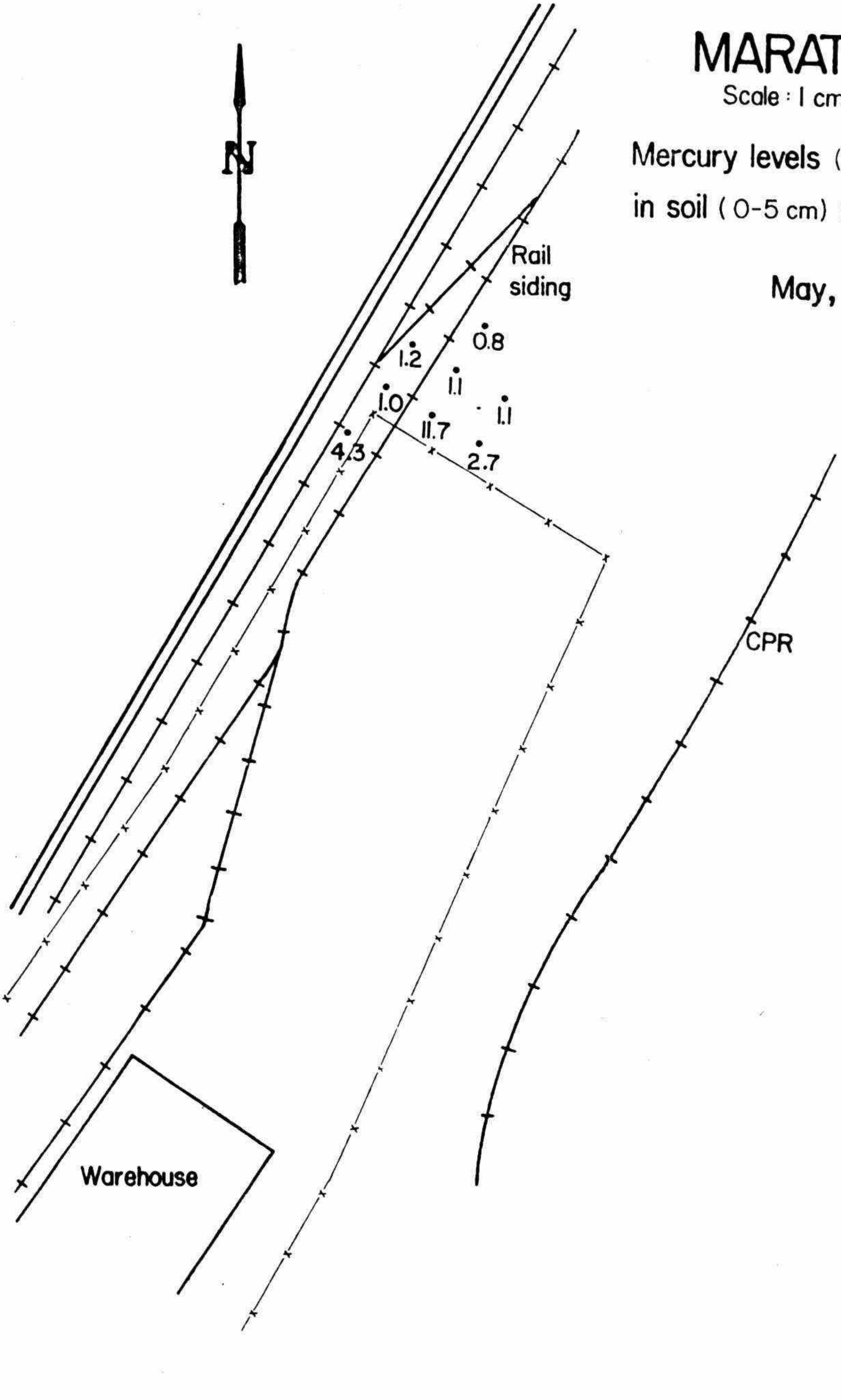
MARATHON

Scale : 1 cm = 43 m

Contour map of mercury levels (ppm) in soil (10-15cm), May, 1976

• = <1 ppm
+ = 1-5 ppm
x = 5-7 ppm
θ = 7-10 ppm
⊗ = 10-15 ppm
■ = >15 ppm

FIGURE 8



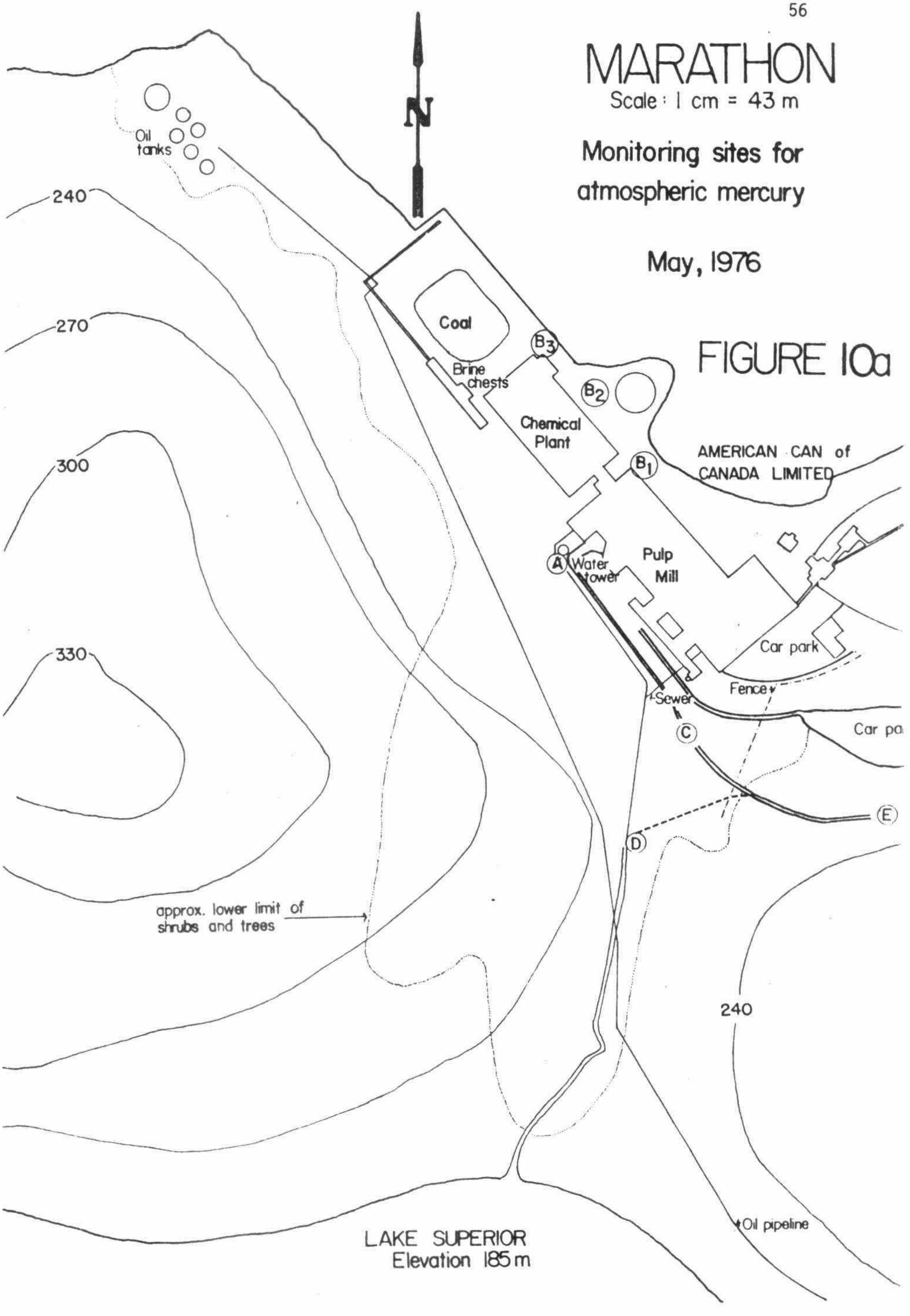
MARATHON

Scale : 1 cm = 10 m

Mercury levels (ppm, dry weight) in soil (0-5 cm) near warehouse

May, 1976

FIGURE 9



MARATHON
Scale : 1 cm = 43 m

Monitoring sites for atmospheric mercury

May, 1976

FIGURE 10a

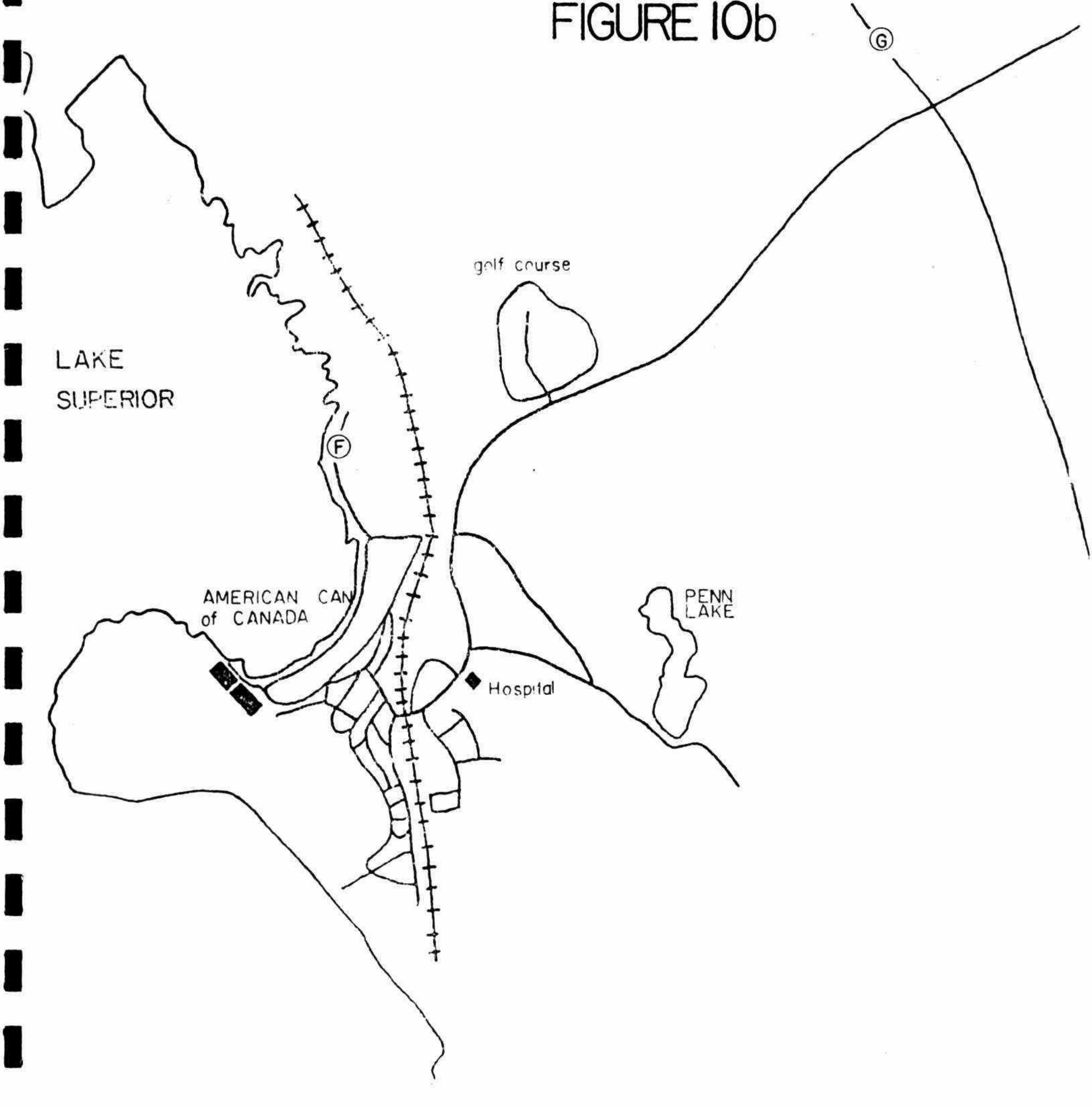
MARATHON

Scale: 1 cm = 317 m

Monitoring sites for
atmospheric mercury

May, 1976

FIGURE 10b



CONCENTRATION VS TIME

SURVEY: MARATHON 024 (SITE B_2)
DATE: MAY 20 1976
SCAN TIME: 60 SEC
STANDARD: 5 UG/M3
LOCATION: INSIDE PLANT, N OF CELL ROOM

POLLUTANT: HG
START TIME: 15:15
AVERAGING TIME: 30 MIN
DISTANCE: .10KM, 0DEG FROM AM. CAN

FIGURE II

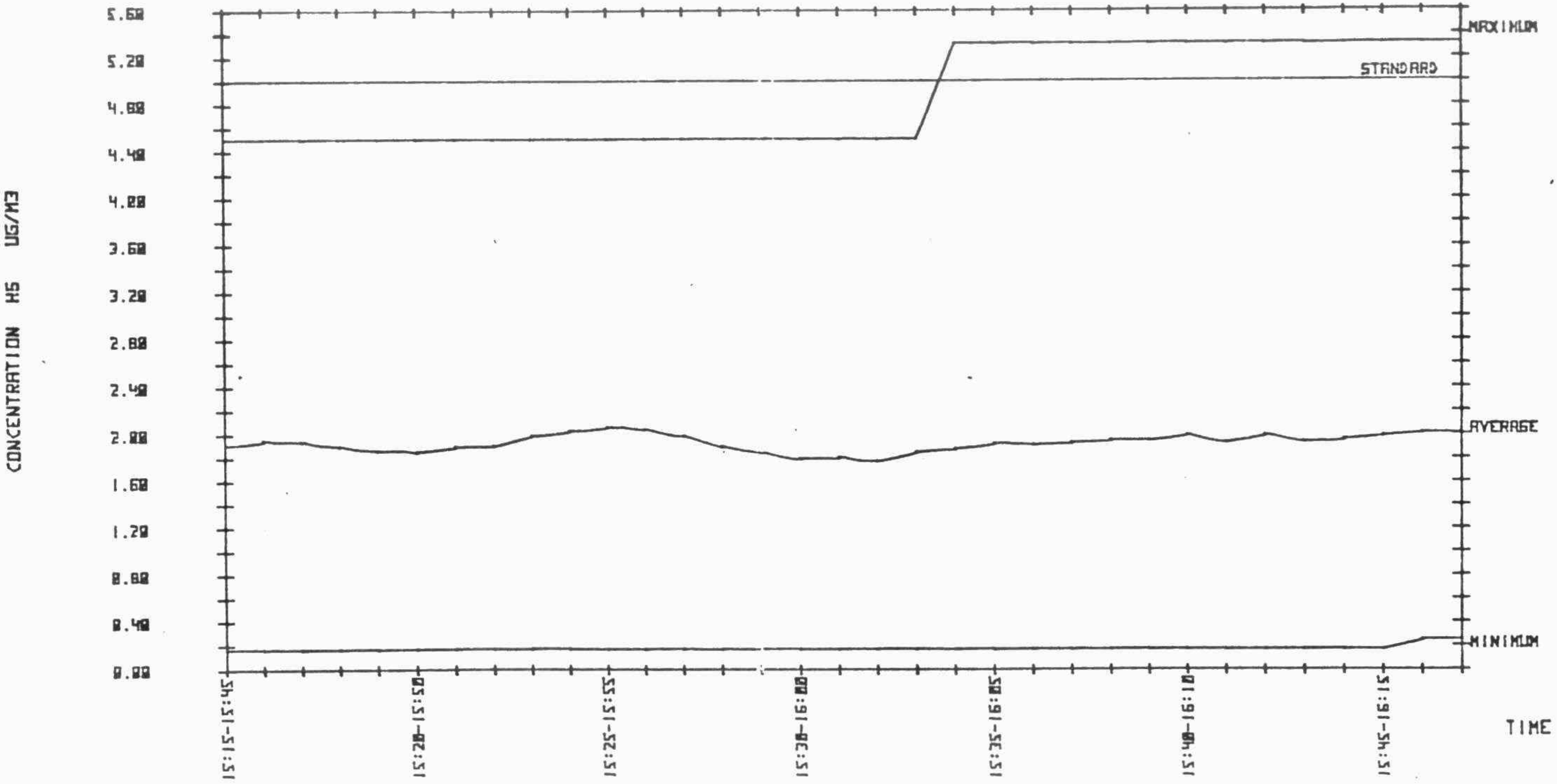


FIGURE 42

CONCENTRATION VS TIME

SURVEY: MARATHON #33 (SITE A)
DATE: MAY 21 1976
SCAN TIME: 60 SEC
STANDARD: 5 UG/M3
LOCATION: WATER TOWER (FUNNEL ON CATWALK)

POLLUTANT: HG
START TIME: 15:32
AVERAGING TIME: 30 MIN
DISTANCE: .03KM, 200DEG FROM AM.CAN

FIGURE 12

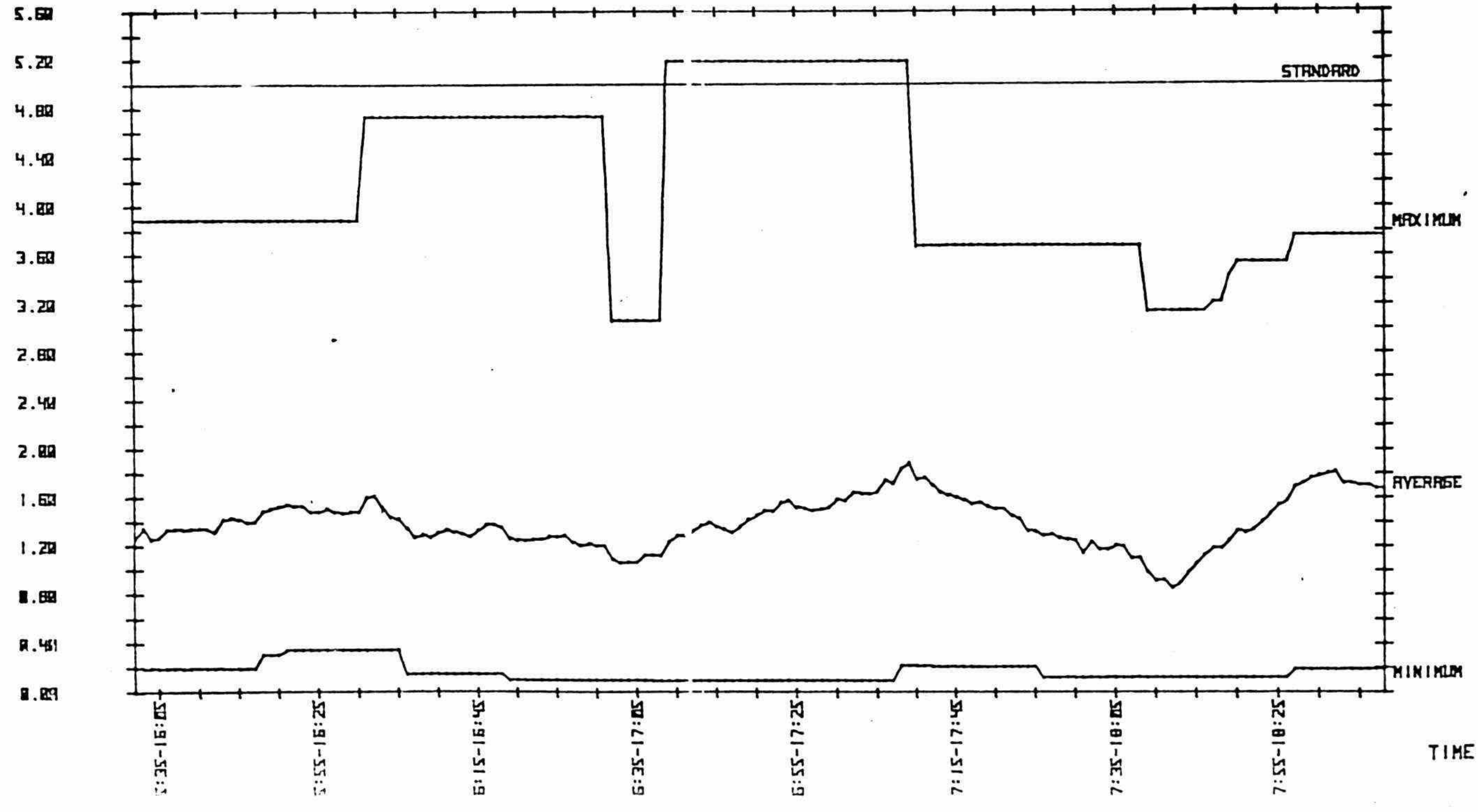


FIGURE 48

FIGURE 13
FISH SAMPLING LOCATIONS
PENINSULA HARBOUR, 1975–6

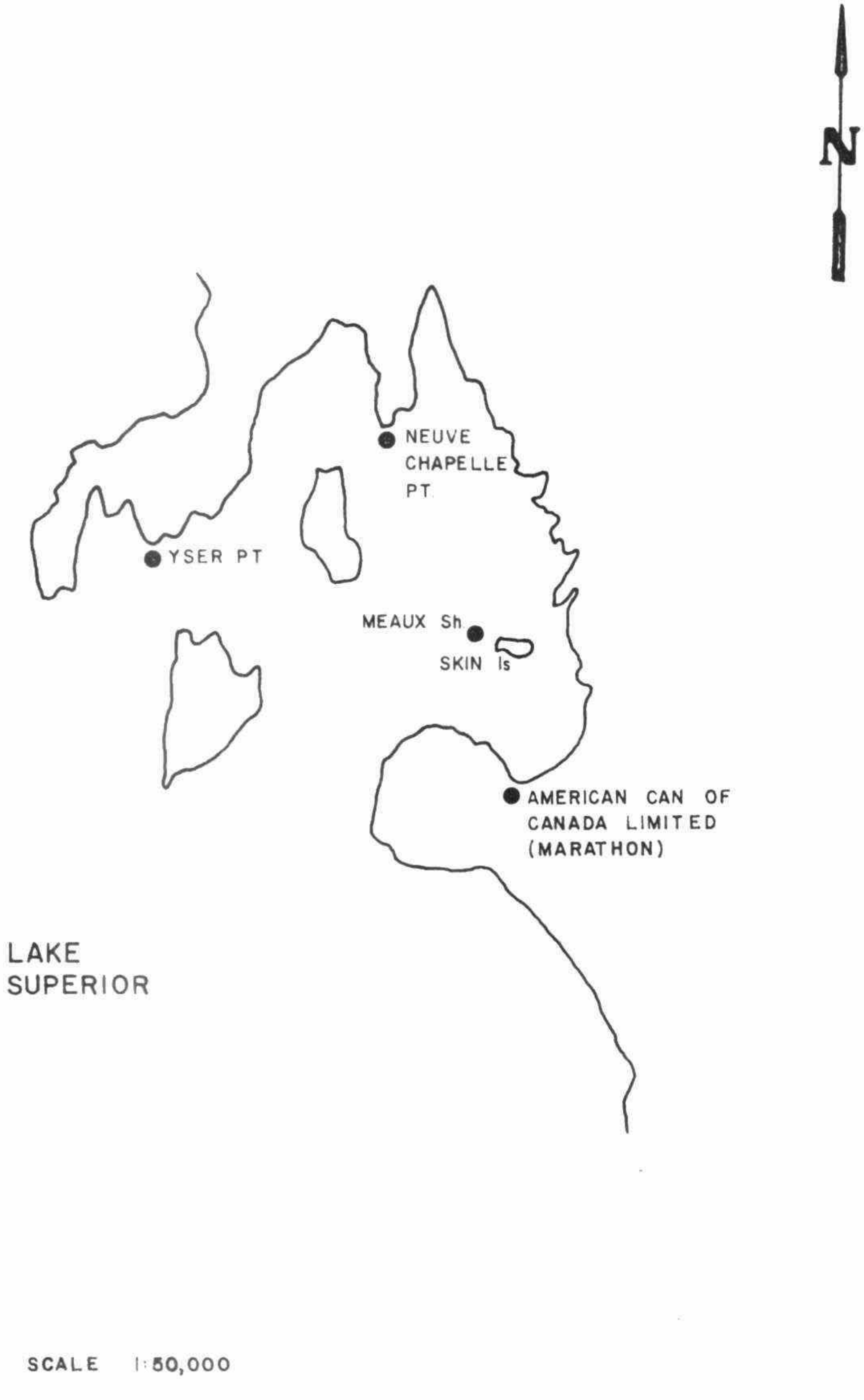


FIGURE 14

BOTTOM FAUNA SAMPLING STATIONS, PENINSULA HARBOUR, LAKE SUPERIOR, 1976

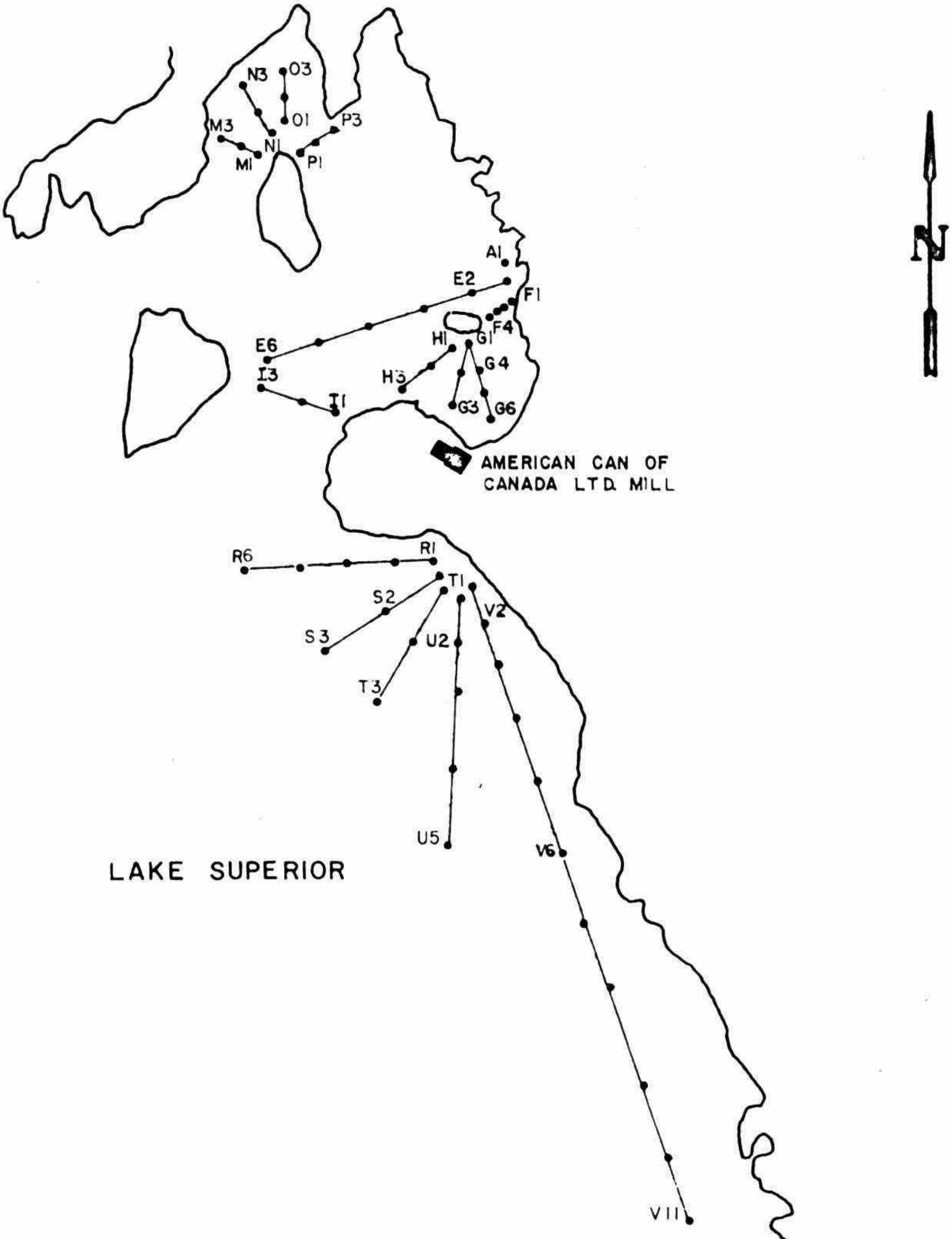
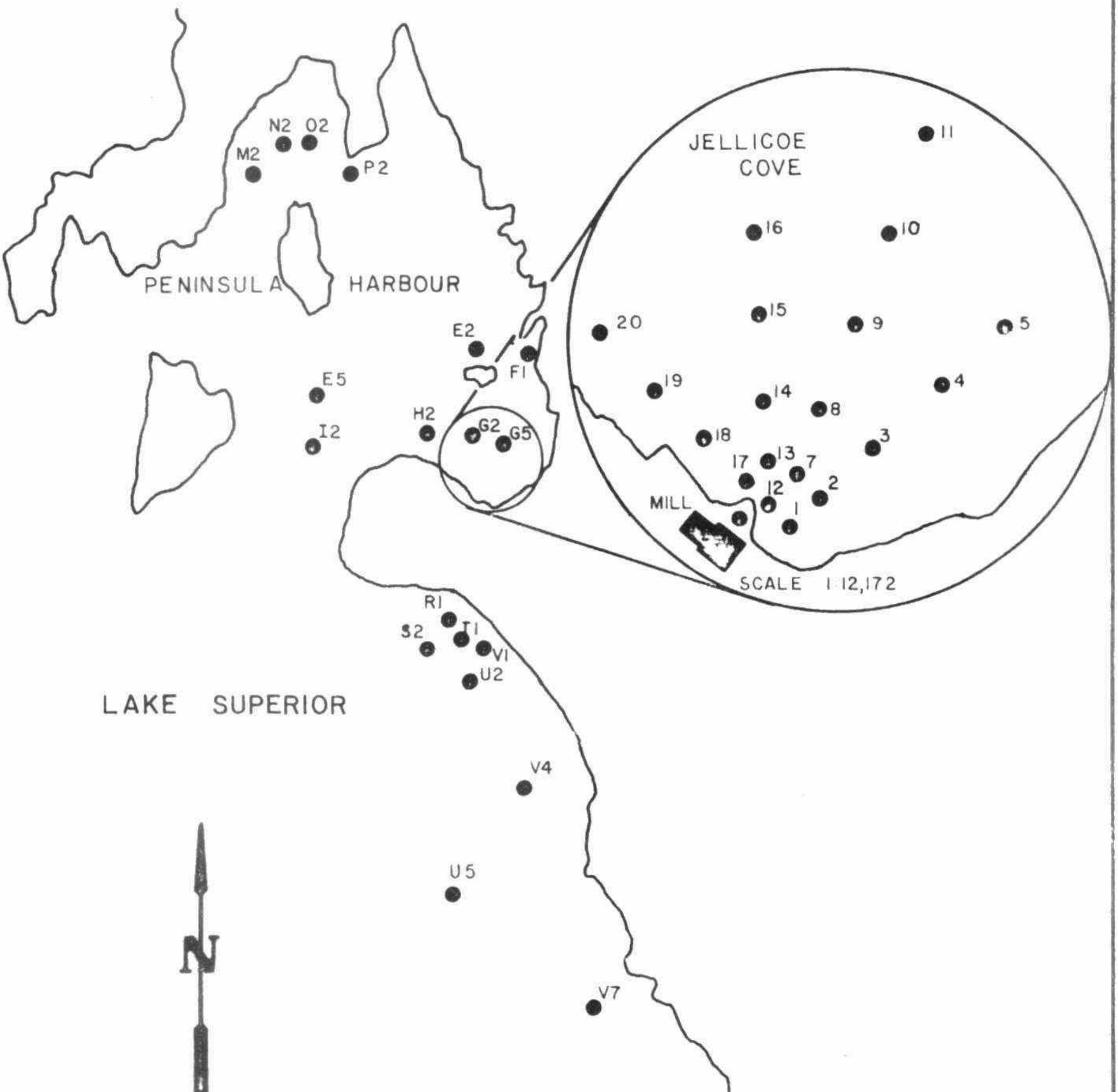


FIGURE 15
SEDIMENT SAMPLING STATIONS
JELLICOE COVE, PENINSULA HARBOUR
AND LAKE SUPERIOR, 1976



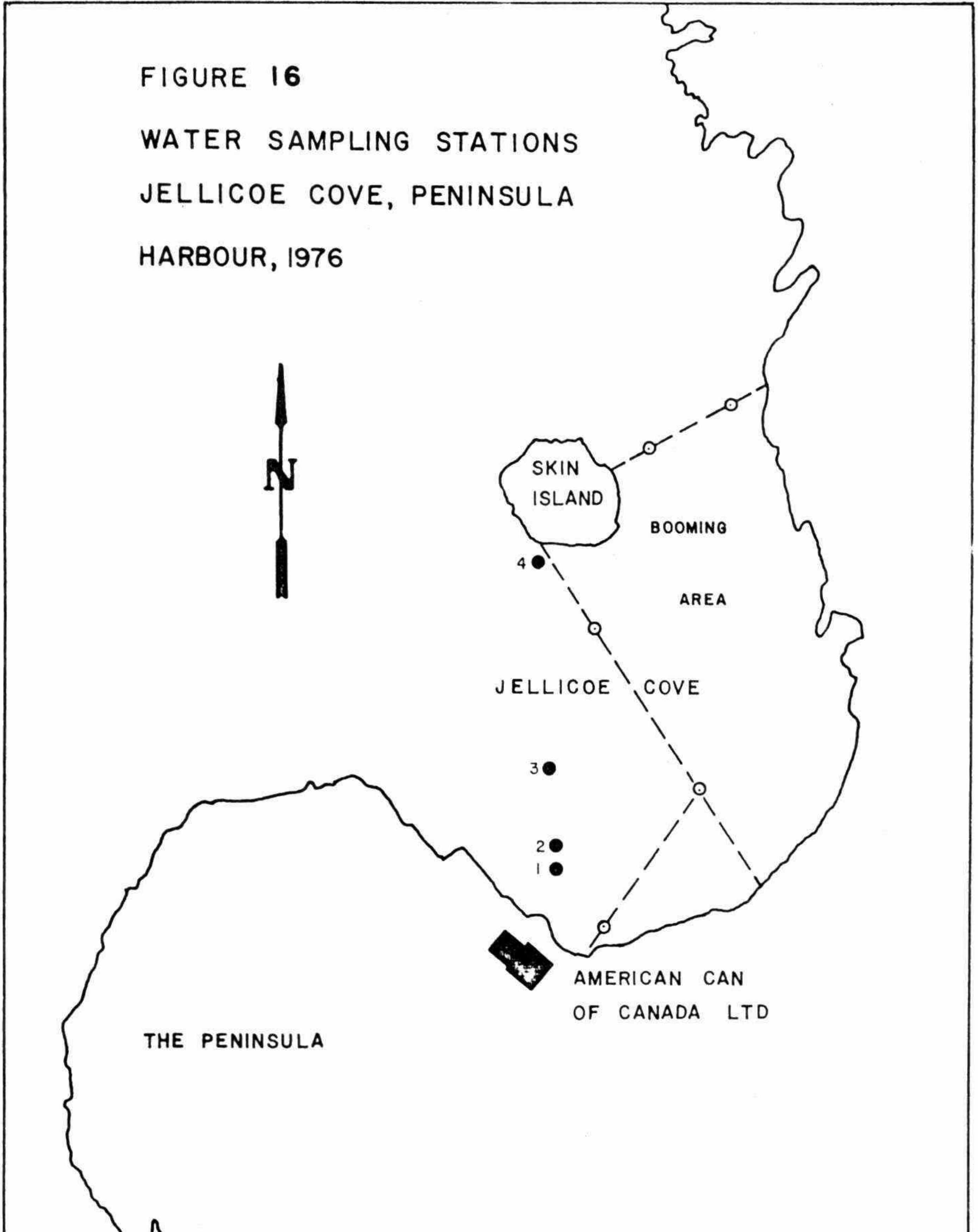


FIGURE 16

WATER SAMPLING STATIONS
JELLICOE COVE, PENINSULA
HARBOUR, 1976

FIGURE 17

NUMBERS OF *Pontoporeia affinis*
VS DEPTH, PENINSULA HARBOUR
LAKE SUPERIOR, 1976

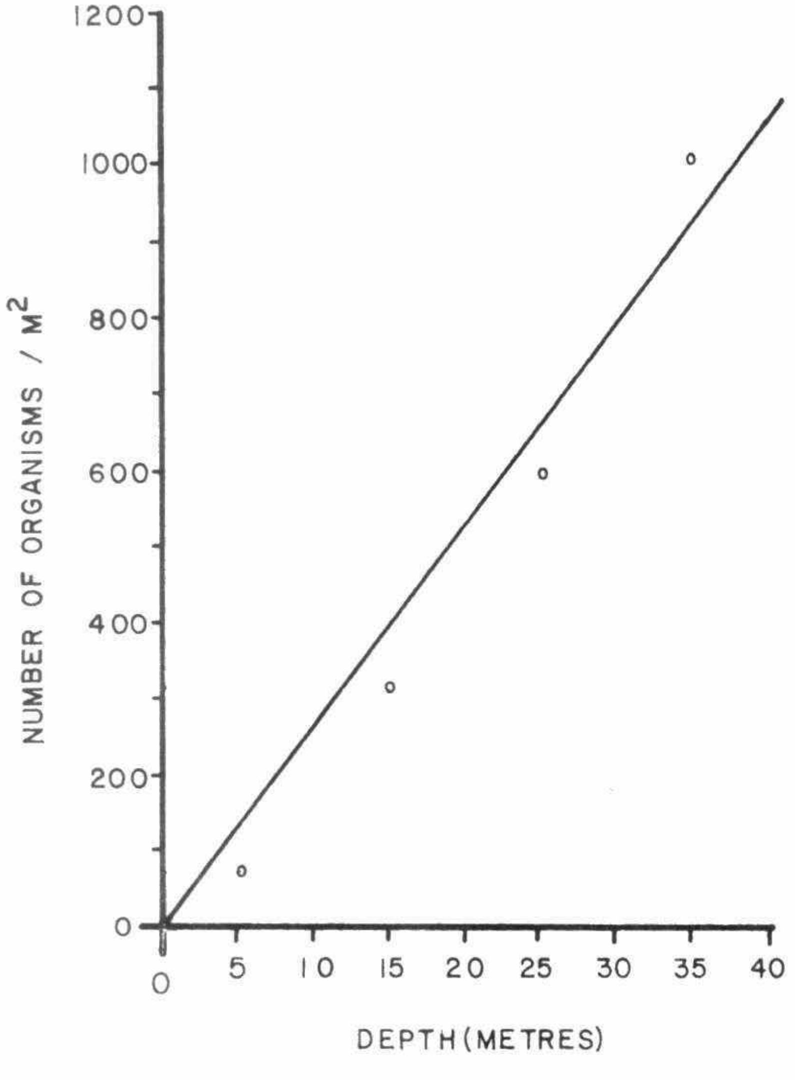


FIGURE 18

MERCURY CONCENTRATIONS IN SEDIMENT, JELLICOE COVE, 1976

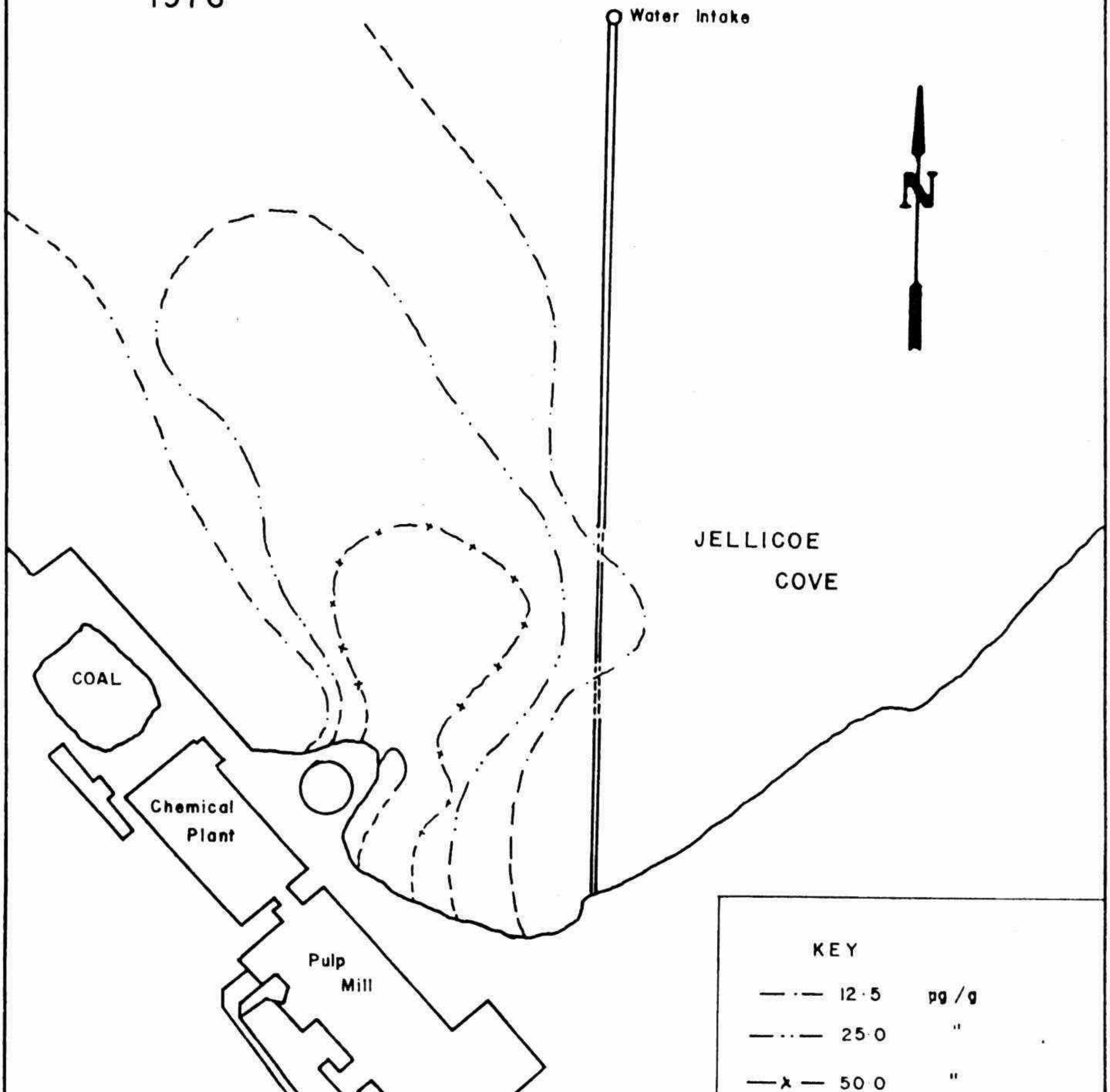
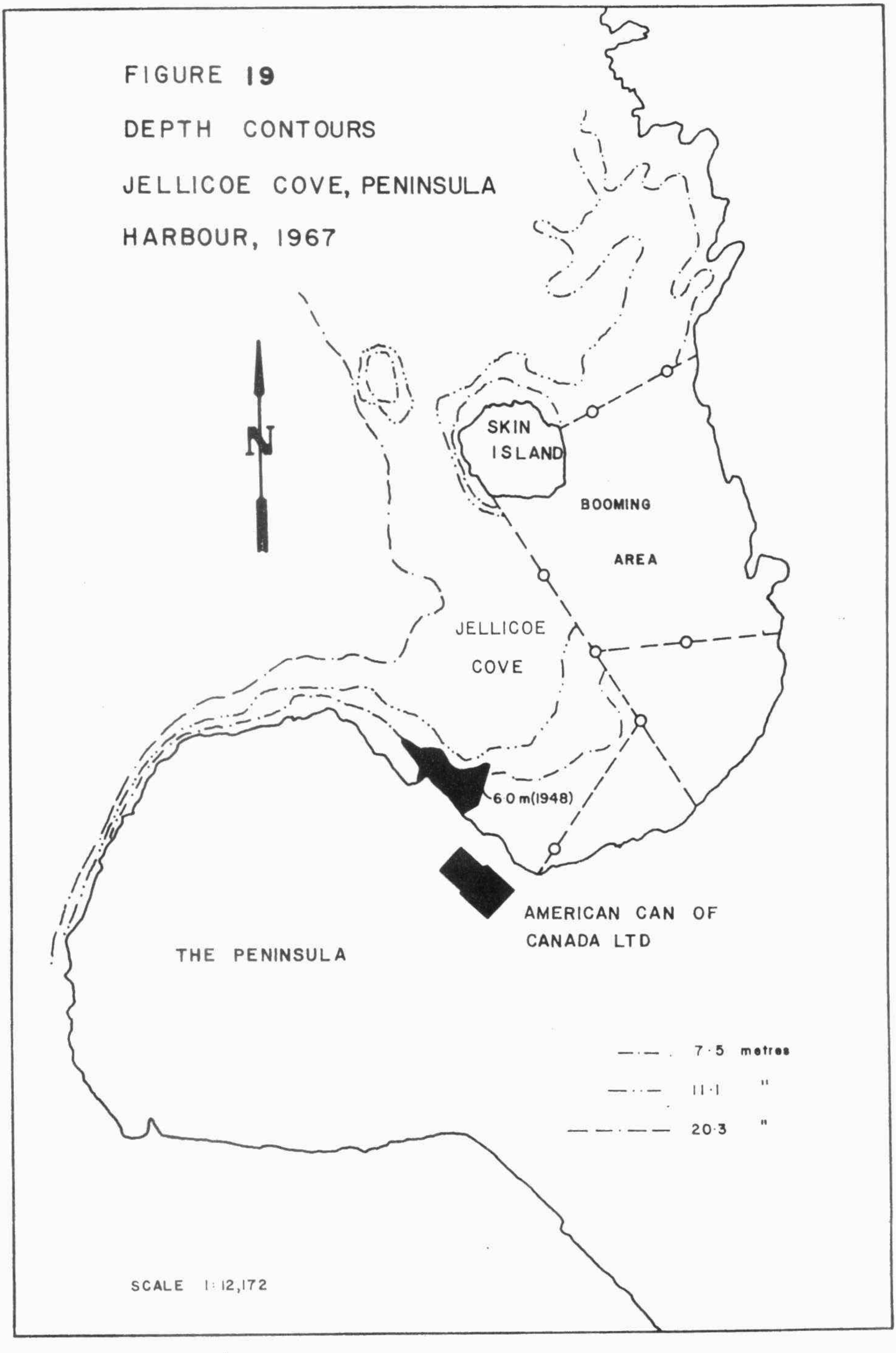


FIGURE 19

DEPTH CONTOURS

JELLICOE COVE, PENINSULA

HARBOUR, 1967



APPENDIX A

SURVEY - PENINSULA HARBOUR
FISH SAMPLING
1975
September 16, 17, 18

---

1. Net set at 17:30 hrs., September 15, 1975.

   Depth - 8 meters to 15 meters.
   Nets - 50 feet each of 1.5", 2.0", 3.5", 4.0" and 4.5" = 250 ft.
   Location - northeast to southwest line towards Blondin Island from Neuve Chapelle Point.

   Net lifted at 10:00-11:00 hours, September 16, 1975.

   Fish No. 1-41 - 1960 to 2000.

2. Net set at 11:30 hours, September 16, 1975. .

   Depth - 13 meters to 20 meters.
   Nets - 50 feet each of 3.0", 3.5" and 4.5" = 150 ft.
   Location - west of Meaux Shoal, west of Skin Island.

   Net lifted at 17:30 hours, September 16, 1975.

   Net sizes 1.5 and 2.0 were removed as too many small fish were caught in first setting.

   Fish No. 42-44 - 2001 to 2003.

3. Net set at 18:15 hours, September 16, 1975.

   Depth - 7.5 meters to 10.5 meters.
   Nets - 50 feet each of 3.0", 3.5" and 4.5" = 150 ft.
   Location - due s~~ou~~th of Yser Point.

   Net lifted at 09:00 hours, September 17, 1975.

   Fish No. 45-64 - 2004 to 2023.

PENINSULA HARBOUR

September 16-17, 1975

Sender No.	Fish No.	Species	Description	Weight gms	Length cm	Sex	Hg ppm
1960	1	Whitefish		653.2	43	-	.99
1961	2	"		426.0	39	-	.81
1962	3	"		426.0	38	-	.60
1963	4	"		596.4	44	-	.73
1964	5	"		484.5	36	-	.97
1965	6	"		541.5	39	-	1.45
1966	7	"		741.0	43	-	1.03
1967	8	"		370.5	33	-	.57
1968	9	"		270.8	30	-	.59
1969	10	"		171.0	37	-	.36
1970	11	Lake Trout		3078.0	66	-	.68
1971	12	Rainbow Trout		426.0	33	-	.49
1972	13	Burbot		627.0	47	-	1.08
1973	14	Gizzard Shad		114.0	20	-	.26
1974	15	"		142.5	22	-	.27
1975	16	"		99.8	19	-	.26
1976	17	"		114.0	20	-	.23
1977	18	"		85.5	18	-	.18
1978	19	"		71.3	16	-	.23
1979	20	"		85.5	19	-	.27
1980	21	White Sucker		627.0	38	-	1.02
1981	22	"		342.0	31	-	.56
1982	23	"		228	27	-	.55
1983	24	"		218.8	26	-	.64
1984	25	"		242.3	27	-	.58
1985	26	"		171.0	23	-	.50
1986	27	Longnose Sucker		769.5	40	-	1.44
1987	28	"		997.5	44	-	2.10
1988	29	"		1111.5	46	-	1.94
1989	30	"		1068.8	45	-	2.60
1990	31	"		755.3	41	-	1.40
1991	32	"		598.5	37	-	1.27

PENINSULA HARBOUR, September 16-17, 1975

Sender No.	Fish No.	Species	Description	Weight gms	Length cm	Sex	Hg ppm
1992	33	Longnose Sucker		712.5	39	-	1.06
1993	34	"		484.5	36	-	.30
1994	35	"		769.5	40	-	1.1
1995	36	"		598.5	37	-	1.29
1996	37	"		270.8	28	-	.60
1997	38	"		285.0	28	-	.46
1998	39	"		228.0	26	-	.38
1999	40	"		299.3	29	-	.64
2000	41	"		299.3	29	-	.43
2001	42	Lake Trout	No right pectoral fin	3163.0	63	-	1.94
2002	43	Whitefish		45.0	38	-	.94
2003	44	"		570.0	39	-	.96
2004	45	Lake Trout	3 scars	2308.0	63	M	.73
2005	46	"	No right pectoral fin	2565.0	70	M	.50
2006	47	"	"	2565.0	66	F	1.45
2007	48	"	"	2565.0	66	F	.72
2008	49	Rainbow Trout		484.0	36	M	.44
2009	50	Longnose Sucker		256.0	29	-	.30
2010	51	"		171.0	25	-	.40
2011	52	"		370.0	34	-	.22
2012	53	"		256.0	28	-	.09
2013	54	"		213.0	26	-	.56
2014	55	"		256.0	30	-	.43
2015	56	"		199.0	27	-	.28
2016	57	"		484.0	33	-	.48
2017	58	"		285.0	31	-	.35
2018	59	"		684.0	40	-	.65
2019	60	"		228.0	27	-	.33
2020	61	Whitefish		627.0	41	-	.37
2021	62	"		370.0	37	-	.30
2022	63	"		460.0	40	-	.36
2023	64	Burbot		460.0	40	-	.96

SURVEY - PENINSULA HARBOUR

FISH SAMPLING

May 18-21, 1976

1. Net set at 1800 hours May 18.
Location - Northeast to southwest line towards
Blondin Island from Neuve Chapelle Point
Nets - 50 feet each 4.5,", 4.0", 3.5" and 3.0" mesh sizes.
Duration - 17 hours.
Net Lifted - 0900 hours, May 19, 1976.

Fish No. 1. Sender's #165(1)

2. Net set at 1815 hours, May 19, 1976.
Nets - as above.
Location - east of Meaux Shoal, and west of Skin Island,
northwest line.
Duration - 16 hours.
Net Lifted - 0815 hours, May 20, 1976.

Fish No. 2-5. Sender's #174(10), 177(13), 183(19) & 189(25)

3. Net set at 1745 hours.
Nets as above.
Location - Due south of Yser Point.
Duration - 16 hours.
Net lifted 0945 hours, May 21, 1976.

Fish No. 6-9. Sender's #168(4), 171(7), 180(16) & 186(22)

PENINSULA HARBOUR

May 18-21, 1976

Sender No.	Fish No.	Species	Weight gms	Length cm	Hg ppm
165	1	Rainbow Trout	2325	60	0.84
174	2	Whitefish	454	39	0.64
177	3	Rainbow Trout	1647	38	1.35
183	4	Pike	2722	69	0.67
189	5	Burbot	284	37	1.84
168	6	Rainbow Trout	4139	69	0.68
171	7	Rainbow Trout	3175	65	0.81
180	8	Rainbow Trout	3402	66	0.84
186	9	Rainbow Trout	454	39	0.61

SURVEY - PENINSULA HARBOUR

FISH SAMPLING

September 21-24, 1976

1. NEUVE CHAPELLE POINT

Net Set

i. 1545, 21-9-76
4-6 m of depth
50' of 2", 3" and 4" mesh respectively
Lifted 0915, 22-9-76
Duration 17.50 hours
Fish #29-46 Sender's #2878-2895

ii. 0930, 22-9-76
2-4.5 m of depth
50' each of 2" and 3", 100' of 4"
Lifted 0930, 23-9-76
Duration 24.00 hours
Fish #59-84 Sender's #2902-2927

2. SKIN ISLAND

Net Set

i. 1645, 21-9-76
5-10 m of depth
50' each of 2.5", 3.5" and 4.5"
Lifted 0845, 22-9-76
Duration 16.0 hours
Fish #6-9 Sender's #2873-2876

ii. 0900, 22-9-76
4-9' m of depth
50' each of 2.5", 3.5" and 4.5"
Lifted 0845, 23-9-76
Duration 23.75 hours
Fish #47-52 Sender's #2896-2901

iii. 1030, 23-9-76
4-9 m of depth
50' each of 2" and 3", 100' of 4"
Lifted 0915, 24-9-76
Duration 22.75 hours
Fish #151 Sender's #2948

3. YSER POINT

Net Set

i. 1015, 22-9-76
3-4 m of depth
50' each of 1.5", 2" and 3"
Lifted 1045, 23-9-76
Duration 24.5 hours
Fish #111-130 Sender's #2928-2947

PENINSULA HARBOUR, SEPTEMBER 21-24, 1976

Sender's No.	Fish No.	Species	Weight (gm)	Length (cm)	Hg (ppm)
NEUVE CHAPELLE PT.					
2878	29	Lake Trout	5108.4	77.5	.82
2879	30	" "	2838.0	65.5	1.30
2880	31	" "	3462.4	69.0	1.20
2881	32	" "	2951.5	69.0	1.00
2902	59	" "	3178.6	68.0	1.10
2903	60	" "	3065.0	66.5	.95
2904	61	" "	2781.2	65.0	.85
2905	62	" "	2838.0	64.5	1.60
2906	63	" "	3604.3	68.0	1.00
2907	64	" "	3434.0	68.0	.71
2908	65	" "	3490.7	66.0	1.20
2909	66	" "	3235.3	70.0	.72
2910	67	" "	3746.2	69.0	.81
2911	68	" "	3519.1	67.0	1.10
2912	69	" "	3689.4	71.0	1.10
2913	70	" "	3519.1	71.0	0.76
2882	33	Whitefish	964.9	45.0	2.00
2883	34	"	227.0	31.0	0.60
2914	71	"	567.6	38.0	0.92
2915	72	"	454.1	38.0	0.94
2916	73	"	794.6	43.5	2.10
2917	74	"	397.3	38.0	1.20
2918	75	"	567.6	40.0	0.62
2919	76	"	567.6	41.0	1.40
2920	77	"	454.1	36.0	0.48
2921	78	"	454.1	40.0	1.60
2922	79	"	340.6	32.0	0.52
2884	35	Longnose Sucker	1021.7	47.0	1.9
2885	36	"	340.6	31.5	.40
2886	37	"	113.5	21.5	.62
2887	38	"	113.5	25.0	.91
2888	39	"	141.9	24.5	.60
2889	40	"	113.5	23.5	.07
2890	41	"	113.5	22.5	.65
2891	42	"	113.5	23.0	.62
2892	43	"	85.1	20.5	.60
2893	44	"	113.5	22.5	.75
2894	45	"	113.5	22.5	.18
2895	46	"	141.9	22.0	.50
2923	80	"	1021.7	45.0	.80
2924	81	"	141.9	23.0	.44
2925	82	"	141.9	23.0	.48
2926	83	"	113.5	22.0	.58
2927	84	"	141.9	23.0	.60

Sender's No.	Fish No.	Species	Weight (gm)	Length (cm)	Hg (ppm)
MEAUX SHOAL					
2873	6	Whitefish	454.1	38.0	.32
2874	7	Longnose Sucker	681.1	40.0	1.90
2875	8	"	227.0	25.5	.55
2876	9	"	227.0	30.0	.65
2900	51	"	1078.4	45.5	.84
2901	52	"	681.1	37.0	1.80
2948	151	"	1021.7	42.5	1.90
2896	47	Lake Trout	3178.6	65.0	.73
2897	48	" "	3575.9	70.0	.87
2898	49	" "	3008.3	63.0	.89
2899	50	" "	4711.1	76.0	.98
YSER POINT					
2928	111	Lake Trout	2781.2	64.0	1.00
2929	112	" "	3632.6	70.0	.88
2930	113	" "	4686.7	70.5	1.00
2931	114	" "	3575.9	65.0	.82
2932	115	" "	2838.0	66.5	.98
2933	116	" "	3547.5	70.0	.85
2934	117	" "	2554.2	65.0	.88
2935	118	" "	2951.5	66.0	1.9
2936	119	" "	3178.6	67.0	.98
2937	120	" "	2859.7	70.0	.85
2938	121	" "	3462.4	67.5	1.00
2939	122	" "	3575	71.0	.82
2940	123	" "	3178.6	68.0	.80
2941	124	Whitefish	454.1	38.0	.23
2942	125	"	397.3	37.0	.24
2943	126	"	283.8	33.0	.08
2944	127	"	510.8	39.0	.70
2945	128	"	454.1	36.0	.24
2946	129	"	283.8	32.0	1.30
2947	130	Longnose Sucker	567.6	37.5	2.1

APPENDIX B

PENINSULA HARBOUR-LAKE SUPERIOR MACROINVERTEBRATES

AVERAGE COLLECTED PER SQUARE METER AT EACH TRANSECT

1969-1976

TAXA	A 1969	A 1976	B 1969	C 1969	D 1969
TRUE MIDGE					
Tendipedidae	180	229	83	95	115
MYSID					
Mysis relicta					
ISOPOD					
Asellas militaris	65		11	697	96
Lirceus	27				
AMPHIPOD					
Gammarus	3		8	352	29
Hyalella azteca					
Pontoporeia affinis	191	38	239	368	697
SLUDGE WORMS					
Oligochaeta	27	115	65	161	566
FLAT WORMS					
Dugesia					
HIRUDINEA					
Erpobdella				22	
GASTROPODA					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
PELECOPODA					
Pisidium	3	19	8	6	9
Sphaerium					
TOTAL TAXA	7	4	6	7	6
TOTAL INDIVIDUALS	496	401	414	1701	1512
DEPTH OF SAMPLE	5.4	5.5	7.1	14.2	14.8

TAXA	E 1969	E 1976	F 1969	F 1976	G 1969	G 1976
TRUE MIDGE						
Tendipedidae	289	146	534	310	143	146
MYSID						
Mysis relicta						
ISOPOD						
Asellas militaris	64	19	642	405	223	299
Lirceus						
AMPHIPOD						
Gammarus	29		51	14	19	
Hyalella azteca						
Pontoporeia affinis	1317	445	127	19	795	89
SLUDGE WORMS						
Oligochaeta	636	627	528	604	4987	802
FLAT WORMS						
Dugesia						
HIRUDINEA						
Erpobdella						
GASTROPODA						
Lymnaea		6				
Helisoma		3				
Valvata sincera		6				
V. tricarinata						
PELECOPODA						
Pisidium	19	54	13		293	64
Sphaerium		26				
TOTAL TAXA	6	9	6	5	6	5
TOTAL INDIVIDUALS	2343	1332	1895	1352	7812	1400
DEPTH OF SAMPLE	20.0	24.9	3.9	6.6	10.5	11.7

TAXA	H 1969	H 1976	I 1969	I 1976
TRUE MIDGE				
Tendipedidae	140	38	76	76
MYSID				
Mysis relicta	13		6	44
ISOPOD				
Asellas militaris	108		32	19
Lirceus				
AMPHIPOD				
Gammarus	25		13	
Hyalella azteca				51
Pontoporeia affinis	1119	159	2939	986
SLUDGE WORMS				
Oligochaeta	11,870	611	2424	614
FLAT WORMS				
Dugesia				
HIRUDINEA				
Erpobdella				
GASTROPODA				
Lymnaea				
Helisoma				
Valvata sincera				
V. tricarinata				
PELECOPODA				
Pisidium	51	44	89	76
Sphaerium		13		
TOTAL TAXA	7	5	7	7
TOTAL INDIVIDUALS	13,326	865	5579	1866
DEPTH OF SAMPLE	17.4	20.6	48.4	44.6

TAXA	J 1969	K 1969	L 1969	M 1969	N 1976
TRUE MIDGE					
Tendipedidae	210	19	165	343	51
MYSID					
Mysis relicta					
ISOPOD					
Asellas militaris				210	6
Lirceus					
AMPHIPOD					
Gammarus	29		32	201	
Hyalella azteca					
Pontoporeia affinis	2939	458	1323	1832	935
SLUDGE WORMS					
Oligochaeta	1079	134	216	811	1107
FLAT WORMS					
Dugesia					
HIRUDINEA					
Erpobdella					
GASTROPODA					
Lymnaea					
Helisoma					
Valvata sincera				29	25
V. tricarinata					6
PELECOPODA					
Pisidium	10		19	86	248
Sphaerium					38
TOTAL TAXA	5	3	5	7	8
TOTAL INDIVIDUALS	6133	611	1755	3512	2416
DEPTH OF SAMPLE	37.5	21.8	27.5	24.8	23.1

	N	N	O	O
TAXA	1969	1976	1969	1976
TRUE MIDGE				
Tendipedidae	547	242	159	1037
MYSID				
Mysis relicta				
ISOPOD				
Asellas militaris	32	115	439	611
Lirceus				
AMPHIPOD				
Gammarus	51		140	
Hyalella azteca				
Pontoporeia affinis	1189	693	1126	293
SLUDGE WORMS				
Oligochaeta	700	1024	681	713
FLAT WORMS				
Dugesia		6		
HIRUDINEA				
Erpobdella			6	51
GASTROPODA				
Lymnaea				
Helisoma				
Valvata sincera		25	6	13
V. tricarinata				
PELECOPODA				
Pisidium	108	318	76	369
Sphaerium		44	6	6
TOTAL TAXA	6	8	9	8
TOTAL INDIVIDUALS	2627	2467	2639	3093
DEPTH OF SAMPLE	20.9	19.1	18.4	17.9

TAXA	P 1969	P 1976	Q 1969	R 1969	R 1976
TRUE MIDGE					
Tendipedidae	191	420	67	16	15
MYSID					
Mysis relicta				3	
ISOPOD					
Asellas militaris	201	133	6		4
Lirceus					
AMPHIPOD					
Gammarus	86	38	38		
Hyalella azteca					
Pontoporeia affinis	1202	604	3022	1190	164
SLUDGE WORMS					
Oligochaeta	1613	553	2605	1110	126
FLAT WORMS					
Dugesia					
HIRUDINEA					
Erpobdella					
GASTROPODA					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
PELECOPODA					
Pisidium	295	13	32	57	
Sphaerium					
TOTAL TAXA	6	6	6	5	4
TOTAL INDIVIDUALS	3588	1761	5770	2376	309
DEPTH OF SAMPLE	12.2	14.6	59.4	31.8	24.0

TAXA	S 1969	S 1976	T 1969	T 1976
TRUE MIDGE				
Tendipedidae	35	38	35	19
MYSID				
Mysis relicta			3	
ISOPOD				
Asellas militaris				
Lirceus				
AMPHIPOD				
Gammarus				
Hyalella azteca				
Pontoporeia affinis	1002	13	468	13
SLUDGE WORMS				
Oligochaeta	1257	19	172	
FLAT WORMS				
Dugesia				
HIRUDINEA				
Erpobdella				
GASTROPODA				
Lymnaea				
Helisoma				
Valvata sincera				
V. tricarinata				
PELECOPODA				
Pisidium	41		67	
Sphaerium				
TOTAL TAXA	4	3	5	2
TOTAL INDIVIDUALS	2335	70	745	32
DEPTH OF SAMPLE	25.6	-	23.0	-

	U	U	V	V	W
TAXA	1969	1976	1969	1976	1969
TRUE MIDGE					
Tendipedidae	13	19	14	16	
MYSID					
Mysis relicta					
ISOPOD					
Asellas militaris					
Lirceus					
AMPHIPOD					
Gammarus			3		
Hyalella azteca					
Pontoporeia affinis	121	134	142	33	33
SLUDGE WORMS					
Oligochaeta	26	122	31	5	5
FLAT WORMS					
Dugesia					
HIRUDINEA					
Erpobdella					
GASTROPODA					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
PELECOPODA					
Pisidium	3				
Sphaerium					
TOTAL TAXA	4	3	4	3	2
TOTAL INDIVIDUALS	163	275	190	54	58
DEPTH OF SAMPLE	13.8	8.8	11.0	11.0	9.0

PENINSULA HARBOUR-LAKE SUPERIOR
MACROINVERTEBRATES
AUGUST, 1976
ORGANISMS PER SQUARE METRE

TAXA	A1	E1	E2	E3	E4
TRUE MIDGE					
Tendipedidae	229	401	267		
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris					
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis	38	57	19		95
SLUDGE WORMS					
Oligochaeta	115	229			420
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium	19				115
Sphaerium					
MULLUSCA (SNAILS)					
Lymnaea				38	
Helisoma					
Valvata sincera				38	
V. tricarinata					
TOTAL TAXA	4	3	2	1	3
TOTAL INDIVIDUALS	401	687	286	76	630
DEPTH OF SAMPLE	5.5	5.5	10.9	14.6	25.6

TAXA	E5	E6	F1	F2	F3
TRUE MIDGE					
Tendipedidae	210		744	363	38
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris	115			1469	134
AMPHIPOD					
Gammarus				57	
Hyalella azteca					
Pontoporeia affinis	1202	1298		76	
SLUDGE WORMS					
Oligochaeta	2271	840	1202	191	305
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium	95	115			
Sphaerium	153				
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma	19				
Valvata sincera					
V. tricarinata					
TOTAL TAXA	6	3	2	2	3
TOTAL INDIVIDUALS	4065	2253	1946	2156	305
DEPTH OF SAMPLE	45.5	47.3	6.4	5.5	7.3

TAXA	F4	G1	G2	G3	G4
TRUE MIDGE					
Tendipedidae	95	76	38	172	
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris	19	19	153	19	
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis		172	191	172	
SLUDGE WORMS					
Oligochaeta	878	229	38	267	
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium		57	172	38	19
Sphaerium					
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
TOTAL TAXA	3	5	5	5	1
TOTAL INDIVIDUALS	992	553	592	668	19
DEPTH OF SAMPLE	7.3	14.6	16.4	9.1	11.9

TAXA	G5	G6	H1	H2	H3
TRUE MIDGE					
Tendipedidae	76	515	38		76
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris	1603				
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis			19	229	229
SLUDGE WORMS					
Oligochaeta	3092	1450	782	420	630
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium	19	76	19	38	76
Sphaerium					38
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
TOTAL TAXA	4	3	4	3	4
TOTAL INDIVIDUALS	4790	2041	858	687	1049
DEPTH OF SAMPLE	10.9	7.3	15.5	22.8	23.6

TAXA	I1	I2	I3	M1	M2
TRUE MIDGE					
Tendipedidae	153	57	19	95	57
MYSID					
Mysis relicta	95		38		
ISOPOD					
Asellus militaris	57				19
AMPHIPOD					
Gammarus					
Hyalella azteca		57	95		
Pontoporeia affinis	286	1107	1565	954	1336
SLUDGE WORMS					
Oligochaeta	659	802	382	210	1775
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium	134		95	210	477
Sphaerium					115
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					76
V. tricarinata				19	
TOTAL TAXA	6	3	5	5	6
TOTAL INDIVIDUALS	1384	2023	2194	1488	3855
DEPTH OF SAMPLE	31.9	45.5	50.4	22.8	23.6

TAXA	M3	N1	N2	N3	O1
TRUE MIDGE					
Tendipedidae		95	267	363	134
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris			229	115	76
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis	515	935	515	630	573
SLUDGE WORMS					
Oligochaeta	1336	515	973	1584	401
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia		19			
MULLUSCA (CLAMS)					
Pisidium	57	210	286	458	229
Sphaerium		38	38	57	
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera			19	57	
V. tricarinata					
TOTAL TAXA	3	5	6	6	5
TOTAL INDIVIDUALS	1908	1812	2327	3264	1413
DEPTH OF SAMPLE	22.8	20.9	21.8	14.6	18.3

TAXA	O2	O3	P1	P2	P3
TRUE MIDGE					
Tendipedidae	1660	1317	324	592	344
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris	649	1107	171	191	38
AMPHIPOD					
Gammarus			57	57	
Hyalella azteca					
Pontoporeia affinis	286	19	782	840	191
SLUDGE WORMS					
Oligochaeta	153	1584	401	534	725
HIRUDINEA					
Erpobdella		153			
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium	57	821	38		
Sphaerium		19			
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera		38			
V. tricarinata					
TOTAL TAXA	5	7	5	4	4
TOTAL INDIVIDUALS	2805	5058	1773	2214	1298
DEPTH OF SAMPLE	18.3	17.3	18.3	15.5	10.0

TAXA	R1	R2	R3	R4	R5
TRUE MIDGE					
Tendipedidae			38		38
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris					19
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis		38	76		706
SLUDGE WORMS					
Oligochaeta				171	458
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium					
Sphaerium					
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
TOTAL TAXA	0	1	2	1	4
TOTAL INDIVIDUALS	0	38	114	171	1221
DEPTH OF SAMPLE	3.6	3.6	9.1	45.5	58.2

TAXA	S1	S2	S3	T1	T2
TRUE MIDGE					
Tendipedidae	19	19	76	19	38
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris					
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis	19		19		
SLUDGE WORMS					
Oligochaeta	19		38		
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium					
Sphaerium					
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
TOTAL TAXA	3	1	3	1	1
TOTAL INDIVIDUALS	57	19	133	19	38
DEPTH OF SAMPLE	2.7	4.5	7.3	2.7	-

TAXA	T3	U1	U2	U3	U4
TRUE MIDGE					
Tendipedidae					76
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris					
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis	38			19	573
SLUDGE WORMS					
Oligochaeta			19		134
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium					
Sphaerium					
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
TOTAL TAXA	1	0	1	1	3
TOTAL INDIVIDUALS	38	0	19	19	783
DEPTH OF SAMPLE		2.7	5.5	10.9	11.9

TAXA	U5	V1	V2	V3	V4
TRUE MIDGE					
Tendipedidae	19			115	19
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris					
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis	76	19	134	134	57
SLUDGE WORMS					
Oligochaeta	458				
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium					
Sphaerium					
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
TOTAL TAXA	3	1	1	2	3
TOTAL INDIVIDUALS	553	19	134	249	76
DEPTH OF SAMPLE	12.8	5.5	9.1	12.8	11.9

TAXA	V5	V6	V7	V8	V9
TRUE MIDGE					
Tendipedidae					
MYSID					
Mysis relicta					
ISOPOD					
Asellus militaris					
AMPHIPOD					
Gammarus					
Hyalella azteca					
Pontoporeia affinis	19				
SLUDGE WORMS					
Oligochaeta		57			
HIRUDINEA					
Erpobdella					
FLAT WORM					
Dugesia					
MULLUSCA (CLAMS)					
Pisidium					
Sphaerium					
MULLUSCA (SNAILS)					
Lymnaea					
Helisoma					
Valvata sincera					
V. tricarinata					
TOTAL TAXA	1	1	0	0	0
TOTAL INDIVIDUALS	19	57	0	0	0
DEPTH OF SAMPLE	1.9	12.8	9.1	10.9	9.1

TAXA	V10	V11
TRUE MIDGE		
Tendipedidae	38	
MYSID		
Mysis relicta		
ISOPOD		
Asellus militaris		
AMPHIPOD		
Gammarus		
Hyalella azteca		
Pontoporeia affinis		
SLUDGE WORMS		
Oligochaeta		
HIRUDINEA		
Erpobdella		
FLAT WORM		
Dugesia		
MULLUSCA (CLAMS)		
Pisidium		
Sphaerium		
MULLUSCA (SNAILS)		
Lymnaea		
Helisoma		
Valvata sincera		
V. tricarinata		
TOTAL TAXA	1	0
TOTAL INDIVIDUALS	38	0
DEPTH OF SAMPLE	11.9	16.4

APPENDIX C

STATION #0 TREATED EFFLUENT BATCH DISCHARGE

	MAY 17			MAY 20			MAY 21	
SAMPLE NUMBER	TIME TAKEN	CONC. Hg ppb	SAMPLE NUMBER	TIME TAKEN	CONC. Hg ppb	SAMPLE NUMBER	TIME TAKEN	CONC. Hg ppb
0001	15.15	80,500	0101	07.55	568	0201	15.00	2390
0002	15.20	44,800	0102	08.00	6580	0202	15.05	62.4
0003	15.25	39,200	0103	08.05	163	0203	15.10	23.4
0004	15.30	14,600	0104	08.10	140	0204	15.15	23.6
0005	15.35	11,000	0105	08.15	192	0205	15.20	25.4
0006	15.40	4,700	0106	08.20	137	0206	15.25	24.6
0007	15.45	2,570	0107	08.25	141	0207	15.30	25.0
0008	15.50	1,340	0108	08.30	122	0208	15.35	24.0
0009	15.55	1,100	0109	08.35	115	0209	15.40	20.0
0010	16.00	450	0110	08.40	114	0210	15.45	24.3
0011	16.05	270	0111	08.45	142	0211	15.50	26.1
0012	16.10	91	0112	08.50	125	0212	15.55	21.0
0013	16.15	58	0113	08.55	107	0213	16.00	22.9
0014	16.20	55	0114	09.00	115	0214	16.05	24.8
0015	16.25	57	0115	09.05	150	0215	16.10	25.6
0016	16.30	68	0116	09.10	146	0216	16.15	21.7
0017	16.35	68	0117	09.15	122	0217	16.20	24.7
0018	16.40	52	0118	09.20	114	0218	16.25	63.5
0019	16.45	71	0119	09.25	109	0219	16.30	30.7
0020	16.50	83	0120	09.30	109	0220	16.35	22.0
0021	16.55	68	0121	09.35	113	0221	16.40	24.1
0022	17.00	67	0122	09.40	108	0222	16.45	23.9
0023	17.05	71	0123	09.45	107	0223	16.50	25.5
0024	17.10	62	0124	09.50	103	0224	16.55	19.6
0025	17.15	52	0125	09.55	88	0225	17.00	17.7
0026	17.20	146	0126	10.00	103	0226	17.05	17.4
0027	17.25	71	0127	10.05	104	0227	17.10	17.8
0028	17.30	65	0128	10.10	104	0228	17.15	15.8
0029	17.35	55	0129	10.15	101	0229	17.20	16.8

STATION #0 TREATED EFFLUENT BATCH DISCHARGE (continued)

	MAY 17			MAY 20			MAY 21	
SAMPLE NUMBER	TIME TAKEN	CONC. Hg ppb	SAMPLE NUMBER	TIME TAKEN	CONC. Hg ppb	SAMPLE NUMBER	TIME TAKEN	CONC. Hg ppb
0030	17.40	75	0130	10.20	115	0230	17.25	14.2
0031	17.45	56	0131	10.25	126	0231	17.30	17.6
0032	17.50	64	0132	10.30	115	0232	17.35	17.7
0033	17.55	62	0133	10.35	219	0233	17.40	25.5
0034	18.00	52	0134	10.40	150	0234	17.45	25.5
0035	18.05	35	0135	10.45	134	0235	17.50	44.8
0036	18.10	47	0136	10.50	106			
0037	18.15	46	0137	10.55	139		Average	93
0038	18.20	57	0138	11.00	144			
0039	18.25	52	0139	11.05	200			
0040	18.30	54	0140	11.10	219			
0041	18.35	53	0141	11.15	209			
0042	18.40	92	0142	11.20	189			
0043	18.45	59	0143	11.25	222			
0044	18.50	85	0144	11.30	211			
0045	18.55	89	0145	11.35	237			
			0146	11.40	243			
	Average	4,284	0147	11.45	266			
			0148	11.47	258			
				Average	290			

STATION #1 - CHLOR-ALKALI PLANT SUMP TO TREATMENT TANK

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	12.30	1001	1,680
	13.40	1002	950
	14.15	1003	2,580
	15.15	1004	1,790
	16.00	1005	730
	16.35	1006	1,340
	18.05	1007	1,060
	19.07	1008	560
	20.03	1009	605
	21.09	1010	5,240
	22.00	1011	1,080
	23.15	1012	5,040
May 18	00.07	1013	1,120
	01.02	1014	1,120
	02.04	1015	3,890
	03.10	1016	1,230
	04.01	1017	1,630
	05.03	1018	730
	06.10	1019	950
	07.01	1020	1,570
	08.02	1021	2,450
	09.03	1022	5,310
	10.03	1023	7,300
	11.50	1024	1,430
	12.23	1025	1,220
	13.00	1026	2,050
	14.00	1027	3,930
	15.11	1028	4,590
	16.00	1029	5,330
	17.09	1030	4,760
May 19	08.45	1031	4,040
	09.11	1032	4,150
	10.00	1033	2,310
	11.00	1034	6,160
	12.00	1035	6,660
	12.45	1036	5,510
	14.03	1037	4,520
	15.00	1038	2,920
	16.20	1039	6,370
	17.25	1040	4,050
	18.17	1041	5,000
	19.29	1042	3,650
	20.19	1043	4,150
	21.17	1044	3,480
	22.37	1045	4,180
	23.09	1046	4,470
		Average	3,083

STATION #2 - INSIDE SEWER-PROCESS ROOM

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	12.35	2001	36,700
	13.45	2002	21,300
	14.17	2003	17,900
	15.20	2004	10,100
	16.05	2005	14,600
	16.40	2006	16,800
	18.10	2007	43,700
	19.10	2008	23,500
	20.08	2009	15,700
	21.13	2010	13,500
	22.03	2011	30,200
	23.18	2012	44,800
May 18	00.13	2013	14,600
	01.09	2014	10,100
	02.09	2015	10,000
	03.13	2016	23,500
	04.42	2017	10,600
	05.06	2018	4,500
	06.17	2019	9,200
	07.05	2020	9,600
	08.07	2021	8,180
	09.07	2022	28,700
	10.05	2023	21,500
	11.55	2024	6,160
	12.34	2025	7,670
	13.05	2026	18,500
	14.04	2027	7,900
	15.16	2028	8,600
	16.04	2029	6,500
	17.13	2030	8,000
May 19	08.50	2031	19,300
	09.14	2032	19,700
	10.03	2033	8,500
	11.04	2034	35,500
	12.05	2035	13,300
	12.48	2036	7,170
	14.05	2037	11,100
	15.25	2038	16,800
	16.23	2039	6,270
	17.31	2040	7,840
	18.20	2041	13,800
	19.39	2042	19,500
	20.25	2043	17,600
	21.25	2044	16,000
	22.42	2045	17,600
	23.15	2046	10,400
		Average	16,300

STATION #3 - CAUSTIC SODA (FINAL PRODUCT)

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	12.40	3001	196
	13.48	3002	169
	14.21	3003	187
	15.25	3004	171
	16.07	3005	131
	16.44	3006	138
	18.10	3007	132
	19.12	3008	148
	20.10	3009	116
	21.15	3010	214
	22.05	3011	125
	23.20	3012	118
May 18	00.14	3013	103
	01.13	3014	123
	02.17	3015	197
	03.15	3016	177
	04.46	3017	145
	05.08	3018	129
	06.20	3019	134
	07.10	3020	135
	08.10	3021	144
	09.09	3022	168
	10.07	3023	200
	11.57	3024	126
	12.36	3025	174
	13.09	3026	139
	14.06	3027	163
	15.18	3028	224
	16.07	3029	140
	17.17	3030	197
May 19	08.52	3031	133
	09.16	3032	152
	10.05	3033	116
	11.06	3034	215
	12.09	3035	114
	12.49	3036	63
	14.07	3037	63
	15.28	3038	48
	16.25	3039	36
	17.35	3040	72
	18.22	3041	106
	19.39	3042	128
	20.28	3043	138
	21.28	3044	119
	22.45	3045	130
	23.17	3046	108
		Average	139

STATION #4 - INSIDE SEWER - EXIT CELL ROOM

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	12.40	4001	19,000
	13.53	4002	29,700
	14.29	4003	14,600
	15.30	4004	12,300
	16.12	4005	14,600
	16.45	4006	13,400
	18.15	4007	15,100
	19.18	4008	15,100
	20.13	4009	17,900
	21.19	4010	25,000
	22.10	4011	19,000
	23.22	4012	16,800
May 18	00.15	4013	6,200
	01.14	4014	12,300
	02.20	4015	17,300
	03.18	4016	16,800
	04.48	4017	17,000
	05.17	4018	16,800
	06.24	4019	16,200
	07.15	4020	13,400
	08.12	4021	17,600
	09.11	4022	30,300
	10.10	4023	15,800
	11.59	4024	9,970
	12.37	4025	10,400
	13.11	4026	25,300
	14.11	4027	18,000
	15.21	4028	16,200
	16.09	4029	15,600
	17.22	4030	130,000
May 19	08.54	4031	19,500
	09.18	4032	35,600
	10.07	4033	12,700
	11.40	4034	34,900
	12.14	4035	15,900
	12.52	4036	10,700
	14.20	4037	12,800
	15.30	4038	27,900
	16.28	4039	12,400
	17.37	4040	34,400
	18.24	4041	14,400
	19.42	4042	14,000
	20.32	4043	8,680
	21.31	4044	5,800
	22.47	4045	3,950
	23.28	4046	3,730
		Average	19,200

STATION # 5 - CHLOR-ALKALI PLANT DISCHARGE TO LAKE

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury	
May 17	12.45	5001	58	
	14.00	5002	75	
	14.37	5003	91	
	15.35	5004	6,700	) Taken During A
	16.12	5005	90	) Batch Discharge
	16.40	5006	83	) not included
	18.25	5007	49	) in Average
	19.24	5008	28	
	20.15	5009	24	
	21.24	5010	32	
	22.13	5011	50	
	23.25	5012	62	
May 18	00.19	5013	45	
	01.05	5014	58	
	02.05	5015	72	
	03.10	5016	66	
	04.05	5017	55	
	05.05	5018	123	
	06.30	5019	146	
	07.25	5020	112	
	08.15	5021	138	
	09.14	5022	73	
	10.13	5023	43	
	12.01	5024	41	
	12.44	5025	7.4	
	13.22	5026	39	
	14.20	5027	3.9	
	15.27	5028	30.1	
	16.16	5029	25	
	17.29	5030	28	
May 19	08.55	5031	38	
	09.23	5032	31	
	10.08	5033	28	
	11.15	5034	22	
	12.20	5035	24	
	12.55	5036	20	
	14.22	5037	18	
	15.05	5038	17	
	16.30	5039	30	
	17.49	5040	20	
	18.20	5041	27	
	19.51	5042	39	
	20.38	5043	39	
	21.40	5044	62	
	22.54	5045	51	
	23.40	5046	62	
		Average	49	

STATION #6 - STORM DRAINAGE AND SEEPAGE

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	12.45	6001	49
	14.05	6002	35
	14.40	6003	29
	15.40	6004	26
	16.20	6005	25
	16.52	6006	20
	18.25	6007	30
	19.30	6008	20
	20.20	6009	18
	21.29	6010	28
	22.15	6011	43
	23.30	6012	44
May 18	00.21	6013	64
	01.10	6014	91
	02.05	6015	81
	03.10	6016	168
	04.05	6017	95
	05.05	6018	134
	06.35	6019	52
	07.30	6020	65
	08.20	6021	52
	09.19	6022	36
	10.18	6023	21
	12.05	6024	24
	12.47	6025	23
	13.25	6026	21
	14.25	6027	17
	15.31	6028	18
	16.20	6029	20
	17.34	6030	20
May 19	8.59	6031	20
	09.28	6032	24
	10.13	6033	33
	11.25	6034	17
	12.25	6035	21
	13.00	6036	18
	14.27	6037	17
	15.10	6038	15
	16.35	6039	33
	17.54	6040	25
	18.20	6041	27
	20.07	6042	50
	20.47	6043	91
	21.47	6044	85
	22.58	6045	84
	23.47	6046	55
		Average	43

STATION #7 - COOLING WATER DITCH

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	13.00	7001	1.9
	13.55	7002	3.7
	14.35	7003	5.3
	15.35	7004	2.9
	16.35	7005	2.7
	17.25	7006	3.1
	18.30	7007	2.7
	19.30	7008	3.9
	20.25	7009	4.6
	21.25	7010	2.7
	22.20	7011	2.6
	23.20	7012	3.2
May 18	00.25	7013	1.7
	01.20	7014	2.0
	02.30	7015	2.5
	03.20	7016	1.3
	04.10	7017	33.6
	05.20	7018	2.2
	06.20	7019	2.5
	07.30	7020	1.8
	08.05	7021	3.8
	09.05	7022	2.1
	11.50	7023	2.1
	12.00	7024	2.3
	12.55	7025	4.0
	13.30	7026	1.9
	14.34	7027	1.4
	15.34	7028	2.3
	16.10	7029	3.3
	17.05	7030	1.6
May 19	09.30	7031	1.4
	10.10	7032	2.7
	10.40	7033	1.6
	11.45	7034	3.5
	12.00	7035	4.0
	14.00	7036	5.6
	14.45	7037	1.7
	15.35	7038	4.5
	16.40	7039	2.1
	17.20	7040	2.1
	18.10	7041	1.5
	19.23	7042	2.1
	20.30	7043	1.4
	21.15	7044	1.5
	22.50	7045	1.1
	23.33	7046	1.1
		Average	2.6

STATION #8 - COOLING WATER AND PULP MILL SUMP OVERFLOW TO LAKE

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	13.05	8001	3.4
	14.00	8002	2.1
	14.40	8003	2.1
	15.40	8004	8.1
	16.40	8005	6.1
	17.30	8006	2.5
	18.35	8007	1.7
	19.37	8008	2.2
	20.30	8009	2.1
	21.30	8010	2.4
	22.25	8011	2.0
	23.25	8012	2.6
May 18	00.25	8013	3.4
	01.20	8014	2.5
	02.35	8015	15.0
	03.20	8016	12.3
	04.10	8017	76.1
	05.20	8018	3.9
	06.25	8019	2.6
	07.00	8020	3.5
	08.10	8021	5.3
	09.10	8022	2.4
	11.47	8023	5.3
	12.05	8024	2.8
	12.55	8025	3.1
	13.30	8026	2.6
	14.28	8027	4.4
	15.28	8028	3.8
	16.15	8029	1.3
	17.10	8030	2.0
May 19	09.25	8031	2.2
	10.05	8032	5.8
	10.45	8033	5.4
	11.40	8034	6.3
	12.05	8035	2.8
	14.05	8036	2.5
	14.50	8037	2.5
	15.40	8038	4.0
	16.40	8039	6.8
	17.25	8040	8.9
	18.12	8041	3.1
	19.30	8042	3.3
	20.35	8043	2.8
	21.20	8044	2.9
	22.50	8045	2.5
	23.27	8046	2.4
		Average	3.9

STATION #9 - ALKALINE BLEACHERY

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury	
May 17	13.15	9001	9.9	
	14.05	9002	8.7	
	14.45	9003	9.0	
	15.45	9004	14.6	
	16.45	9005	13.4	
	17.35	9006	13.4	
	18.40	9007	13.4	
	19.45	9008	18.5	
	20.37	9009	12.3	
	21.35	9010	19	
	22.50	9011	19.0	
	23.35	9012	16.8	
May 18	00.35	9013	19.0	
	01.25	9014	13.4	
	02.45	9015	16	
	03.30	9016	13.4	
	04.20	9017	13.4	
	05.25	9018	13.4	
	06.30	9019	12.3	
	07.05	9020	13.4	
	08.15	9021	13	
	09.15	9022	17	
	10.40	9023	14	
	12.10	9024	11	
	12.53	9025	15	
	13.25	9026	14	
	14.23	9027	14	
	15.23	9028	12	
	16.20	9029	10	
	17.15	9030	10	
May 19	9.05	9031	7.9	
	10.00	9032	8.0	
	10.50	9033	6.8	
	11.35	9034	12	
	12.10	9035	10	
	14.10	9036	7.5	
	14.55	9037	14	
	15.45	9038	3.4)	
	16.45	9039	0.54)	Power
	17.35	9040	.28)	
	18.05	9041	0.32)	Failure
	19.35	9042	5.3	
	20.35	9043	7.7	
	21.25	9044	7.6	
	22.45	9045	9.5	
	23.23	9046	11	
		Average	12.4	

STATION #10 - ACID BLEACHERY

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury	
May 17	13.30	10001	5.6	
	14.15	10002	4.5	
	14.50	10003	6.1	
	15.50	10004	9.0	
	16.50	10005	5.4	
	17.40	10006	6.7	
	18.50	10007	6.3	
	20.15	10008	8.3	
	20.50	10009	10.3	
	21.45	10010	9.2	
	22.55	10011	6.3	
	23.50	10012	6.7	
May 18	00.42	10013	5.2	
	01.35	10014	4.9	
	02.50	10015	4.2	
	03.40	10016	6.9	
	04.35	10017	7.2	
	05.32	10018	4.9	
	06.40	10019	4.0	
	07.10	10020	4.0	
	08.25	10021	4.9	
	09.55	10022	4.8	
	10.30	10023	4.9	
	12.20	10024	3.8	
	12.45	10025	2.8	
	13.20	10026	2.6	
	14.15	10027	2.9	
	15.15	10028	2.1	
	16.25	10029	3.2	
	17.20	10030	3.1	
May 19	09.00	10031	1.7	
	09.45	10032	4.1	
	11.00	10033	3.1	
	11.30	10034	2.5	
	12.25	10035	2.7	
	14.25	10036	1.9	
	16.00	10038		Power
	16.55	10039		
	17.50	10040		Failure
	18.20	10041		
	19.40	10042	2.5	
	20.40	10043	3.0	
	21.30	10044	3.3	
	22.35	10045	4.1	
	23.15	10046	4.3	
		Average	4.7	

STATION #11 - MAIN MILL EFFLUENT

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 17	13.30	11001	3.0
	14.15	11002	2.9
	14.50	11003	3.0
	15.55	11004	2.2
	16.50	11005	2.6
	17.40	11006	5.4
	18.50	11007	2.1
	20.30	11008	5.2
	20.50	11009	2.1
	21.45	11010	2.1
	22.55	11011	2.7
	23.50	11012	2.8
May 18	00.42	11013	3.5
	01.35	11014	4.3
	02.50	11015	4.9
	03.40	11016	5.6
	04.35	11017	5.2
	05.35	11018	Sample Broken
	06.40	11019	5.6
	07.10	11020	5.7
	08.25	11021	7.9
	09.55	11022	6.4
	10.30	11023	7.4
	12.20	11024	7.1
	12.45	11025	7.3
	13.20	11026	8.8
	14.15	11027	7.7
	15.15	11028	6.1
	16.25	11029	5.8
	17.20	11030	5.9
May 19	09.00	11031	4.5
	09.45	11032	4.6
	11.00	11033	5.4
	11.30	11034	4.2
	12.25	11035	5.1
	14.25	11036	5.4
	15.05	11037	Power Failure
	16.00	11038	
	16.55	11039	4.3
	17.50	11040	3.0
	18.20	11041	3.6
	19.40	11042	2.0
	20.40	11043	3.0
	21.30	11044	2.1
	22.35	11045	2.4
	23.15	11046	2.5
		Average	4.5

PRODUCTS

SODIUM HYPOCHLORITE

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 20	15.55	2200	3,790
	16.00	2201	3,790
May 19	10.00	3	2,610
May 21	17.48	H1	1,650
		Average	2,960

HYDROCHLORIC ACID

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 20	16.05	2202	595
	16.10	2203	723
May 19	10.00	1	505
May 21	15.47	Hbl 1	480

SODIUM CHLORATE

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 20	16.15	2204	16,200
May 19	10.00	2	9,400
May 21	15.48	51	8,500
		Average	11,400

ADDITIONAL PRODUCT SAMPLING

SODIUM HYPOCHLORITE

DATE	LOCATION	CONCENTRATION ppb Mercury
July 21	Bleach Plant	2,300
July 23	Bleach Plant	3,400
July 23	Bleach Plant	3,500
July 23	Bleach Plant	4,300
July 23	Chlor-Alkali Plant	4,000

SODIUM CHLORATE

DATE	LOCATION	CONCENTRATION ppb Mercury
July 21	Bleach Plant	7,100
July 23	Bleach Plant	4,200
July 23	Bleach Plant	13,000
July 23	Bleach Plant	7,600
July 23	Chlor-Alkali Plant	9,200

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DATE	LOCATION	CONCENTRATION ppb Mercury
July 23	Chlor-Alkali Plant	73

CAUSTIC NaOH (50% Strength)

DATE	LOCATION	CONCENTRATION ppb Mercury
July 21	Bleach Plant	190
July 23	Bleach Plant	620
July 23	Bleach Plant	610
July 23	Bleach Plant	640
July 21	Chlor-Alkali Plant	200
July 23	Chlor-Alkali Plant	1,200
July 23	Chlor-Alkali Plant	190
July 23	Chlor-Alkali Plant	170

SERVICE WATER AT MILL INTAKE

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 20	15.45	5E	0.18
	15.50	6E	0.14
	15.55	78	0.13
	16.00	8E	0.12
May 21	14.50	9E	0.13
	14.54	10E	0.07
	14.58	11E	0.07
	15.02	12E	0.12
	15.15	13E	0.09
	15.19	14F	0.09
	15.23	15E	0.07
	15.27	16E	0.09
May 19	14.38	2E	0.22
	15.50	3E	0.24
May 21	17.23	17E	0.13
		Average	0.126

HYDROGEN VENT TOWER

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 21	15.40	$H_2 1$	840
	16.06	$H_2 2$	1,070
	16.50	$H_2 3$	886

UNFILTERED BRINE (NaCl) TO CELLS

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 20	15.15	3200	9,500
	15.20	3201	9,400
	15.25	3202	6,900
	15.30	3203	7,230
May 21	15.35	BU1	3,070
	16.12	BU2	4,800
	16.37	BU3	5,020
	17.40	BU4	5,110

FILTERED BRINE (NaCl) TO CELLS

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 20	15.23	3204	8,550
	15.28	3205	8,300
	15.33	3206	8,450
	15.38	3207	8,500
May 21	15.37	BF1	2,940
	16.02	BF2	4,450
	16.41	BF3	4,360
	17.37	BF4	4,690

SOURCES TO COOLING WATER DITCH

CHLORINE COMPRESSOR COOLING WATER

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 19	14.32	2B	8.3
	15.44	3B	26.0
May 21	16.04	9B	6.7
	16.47	10B	12.7
	17.32	11B	12.0
May 19		D	4.9

HYDROGEN VENT PRECOOLER WATER

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 19	14.34	2C	0.84
	15.46	3C	1.1
May 21	15.04	9C	1.3
	15.09	10C	2.9
	17.30	11C	0.93
May 19		B	0.61

BRINE HEAT EXCHANGER WATER

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 19	14.30	2A	0.45
	15.40	3A	0.42
May 21	16.00	9A	1.4
	16.23	10A	0.64
	17.35	11A	0.69
May 19		C	2.8

SOURCES TO COOLING WATER DITCH

COMBINED BRINE HEAT EXCHANGER WATER

AND

SODIUM HYPOCHLORITE COOLING WATER

DATE	TIME TAKEN	SAMPLE NO.	CONCENTRATION ppb Mercury
May 19	14.36	2D	1.5
	15.47	3D	0.32
May 21	15.04	9D	0.10
	15.09	10D	0.28
	17.30	11D	0.13
May 19		A	0.26

APPENDIX D

INTRODUCTION

This is an edited version of a report by B. P. Neary, Inorganic Trace Contaminants Section Laboratory Services Branch, Ministry of the Environment; entitled "The Marathon Mercury Survey".

ANALYSIS

The method of analysis for mercury has been described in detail elsewhere (J.N. Bishop, et al., The Determination of Mercury in Environmental Samples, M.O.E. Report, January, 1973) The sample is digested with nitric acid, sulfuric acid, potassium permanganate and potassium persulfate for two hours at 80° C to ensure breakdown of organic materials and to convert all the mercury present to the divalent ion. After cooling, the excess potassium permanganate is reduced with hydroxylamine sulfate, then the mercury is reduced to its elemental state with stannous sulfate. The sample is then aerated, and the resulting stream of air and volatilized mercury is passed through an ultraviolet absorption cell, where the absorption at 253.7 nm is recorded. The absorption is proportional to the mercury concentration of the sample. The limit of detection by this method is approximately 0.05 μg/l (ppb).

The analytical method used in the Marathon field laboratory, and in the Toronto and Thunder Bay MOE laboratories was the same. The typical elapsed time between sampling and analysis for those samples analyzed at all three labs was: 20 hours for Marathon, 5 days for Toronto, and 12 days for Thunder Bay.

RESULTS

The results of those analyses performed at the three laboratories are listed in Table 1. Three statistical methods for the comparison of the three sets of results were used. These techniques were designed for the comparison of two sets of data, so three such comparisons were made: Marathon-Toronto, Marathon-Thunder Bay, and Thunder Bay-Toronto.

The first statistical test used was the paired "t" test. The "t" statistic is calculated from the population of differences between pairs of observations (eg. those analytical results reported in Marathon and those results from Thunder Bay). The hypothesis tested by the statistic is that there is no significant difference in the two populations of results, and a high "t" value results in the rejection of this hypothesis. The t-statistic is the ratio of the difference between the population means, and the standard deviation of the difference.

The second statistic used was the correlation coefficient, r. This is designed to vary between + 1 and - 1 according to the closeness of the relationship between the two sets of results. A coefficient of + 1 indicates a perfect positive correlation, and r = - 1 a perfect negative correlation.

The third statistic was the regression coefficient, b, which is the slope of the line of best fit (least squares) through the points if they are plotted against each other. Two sets of identical results would yield a regression coefficient of + 1.

The results of the statistical analysis are listed in Table 2-4.

DISCUSSION

1) Toronto vs Thunder Bay

The results of the statistical analysis of the comparison between the Tunder Bay and Toronto Laboratories show excellent agreement in the range 0-1,000 (μg/l) (see Table 4). Above 1,000 μg/l, the Toronto results tend to be lower than those reported by Thunder Bay. However, the results over 1,000 ppb are calculated after several dilutions, and the differences observed in the higher concentration ranges are probably an artefact of the multiplication of small dilution errors, rather than differences in analysis.

2) Marathon vs Thunder Bay and Toronto

The results of mercury analyses from the temporary laboratory set up in Marathon, indicate some significant discrepancies (see Tables 2 and 3). However, an inspection of the analytical results (see Table 1) indicates that most of the discrepancies can be attributed to samples from two sampling points: the filtered caustic, and the final discharge from the chlor-alkali plant to the lake.

It has been established that chlorine can cause a positive interference in the analysis of mercury, and there is a strong possibility that the high results obtained by the Marathon laboratory on samples from these points were due to the presence of residual chlorine in the samples at the time of analysis in Marathon. On those same samples, reasonable agreement was obtained between the Toronto and Thunder Bay laboratories, indicating that the chlorine had been oxidized by the preservatives by the time the samples were analyzed at these laboratories.

It is recommended, therefore, that prior to on-site analysis of in-plant samples from chlor-alkali plants, chlorine residual levels be checked, or mercury peak verification via gold trap be performed as part of on-site analyses. Hopefully this will eliminate future discrepancies between on-site and regular laboratory analyses for mercury in industrial samples.

TABLE 1

Analytical Results
(all results in µg/l)

Sample Source	Marathon	Toronto	Thunder Bay
Sump to treatment tank	6100	4600	5200
"	240	3900	4000
"	6500	6100	7300
"	4400	3600	4800
"		6400	6200
Inside Sewer-Process Room	13000	10500	13500
"	8900	9100	10000
"	20900	18000	21500
"	7500	6000	8000
"		31000	35500
Inside Sewer - Cell Room Exit	24000	23000	25000
"	15000	17000	17000
"	18000	16000	16000
"	110000	94000	125000
"		30000	35000
Filtered Caustic	2700	180	210
"	370	240	200
"		190	215
Chlor-Alkali Discharge to Lake	210	37	32
"	450	72	72
"	77	48	43
"	50	27	28
Treated Batch Discharge	69	71	71
"	69	67	67
"	73	69	76
"	66	65	74
"	70	65	68
"		1300	1200
Storm Drainage and Brine Chest Seepage	35	31	28
"	83	86	81
"	23	18	21
"	23	17	20
"		17	17
Cooling Water	2.9	2.9	2.7
"	2.9	2.8	2.5
"	2.0	2.6	2.1
"		1.9	1.6
"		3.9	3.5

Sample Source	Marathon	Toronto	Thunder Bay
Cooling Water and Sump Overflow	3.2	2.9	2.4
	16	15	15
	5.4	5.5	5.3
		2.2	2.0
		7.5	6.3
Alkali Bleachery	22	17	19
	18	16	16
	14	15	14
		14	12
		9.9	10
Acid Bleachery	22	17	19
	18	16	16
	14	15	14
		14	12
		9.9	10
Acid Bleachery	9.9	10	9.2
	5.6	5.2	4.2
	5.6	5.1	4.9
		3.1	2.5
		3.9	.1
Main Mill Effluent	2.6	2.3	2.1
	5.8	5.2	4.9
	9.2	7.9	7.4
		5.1	4.2
		6.8	5.9

TABLE 2: MARATHON VS TORONTO

Concentration Range (µg/l)	N	Mean of Marathon Results	Mean of Toronto Results	Correlation Coefficient r	Regression Coefficient b	t
0-125,000	42	5690	5070	0.998	0.861	1.513
0-10,000	36	1060	960	0.936	0.866	0.716
0-1,000	29	62	36	0.735	0.330	1.817
0-100	26	29	26	0.970	0.907	2.302*
0-10	11	5.0	4.8	0.985	0.911	1.673

* significant at the 0.95 level of probability

TABLE 3: MARATHON VS THUNDER BAY

Concentration Range (µg/l)	N	Mean of Marathon Results	Mean of Thunder Bay Results	Coerrelation Coefficient r	Regression Coefficient b	t
0-125,000	42	5690	6150	0.998	1.125	-1.219
0-10,000	36	1060	1130	0.950	1.032	-0.482
0-1,000	29	62	34	0.728	0.289	1.838
0-100	26	29	27	0.961	0.923	1.824
0-10	11	5.0	4.3	0.983	0.867	3.993*

* significant at the 0.95 level of probability

TABLE 4: TORONTO VS THUNDER BAY

Concentration Range (μg/l)	N	Mean of Toronto Results (μg/l)	Mean of Thunder Bay Results (μg/l)	Correlation Coefficient r	Regression Coefficient b	t
0-125,000	58	4380	5800	0.970	1.287	-1.85
0-10,000	50	850	960	0.994	1.135	-2.078
0-1,000	42	35	35	0.986	1.004	-0.206
0-100	39	22	22	0.995	1.018	0.178
0-10	20	4.8	4.4	0.991	0.967	0.652

* significant at the 0.95 level of probability